East Hampton Town Trustees 2023 Water Quality Study,

Final Report

by

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Executive Summary

This study was undertaken from May through October of 2023 for the East Hampton Town Trustees to assess water quality, harmful algal blooms, pathogenic bacteria, and sediments in the marine and freshwater bodies of Napeague Harbor, Acabonac Harbor, Hog Creek, Three Mile Harbor, Northwest Creek, Swan Pond, Pond Lane, Fresh Pond, Hook Pond, Georgica Pond, Wainscott Pond, and Fort Pond. The study also included continuous monitoring and/or surface mapping of Three Mile Harbor and Georgica Pond because of harmful algal blooms and/or low dissolved oxygen conditions at these sites in the past. During 2023, most East Hampton Town Trustees waters were often of a high quality. Fecal coliform bacteria levels across marine sites were generally low through the spring and summer, although excursions beyond state standards were observed at multiple sites in Acabonac Harbor and Three Mile Harbor in patterns were partly consistent with NYSDEC shellfishing recommendations. In addition, levels of *Enterococcus* exceeded levels recommended for swimming by NYSDOH in both systems on occasion in 2023. Microbial source tracking of fecal bacteria found elevated levels of fecal bacteria from dogs and small mammals, followed by birds for both Three Mile Harbor and Acabonac Harbor. Chlorophyll-*a* levels were usually within a healthy range for most sites although 6 of 14 sites displayed levels above guideline values on at least one occasion during late summer or the beginning of fall. Regarding harmful algal blooms (HABs), Three Mile Harbor experienced an early bloom of the saxitoxin producing HAB, *Alexandrium* in early April at 3,400 cells per liter and a bloom of *Dinophysis* in June at 7,100 cells per liter. In August, Hog Creek, Napeague Harbor, and Accabonac Harbor each experienced a rust tide bloom caused by Cochlodinium with the bloom in Accabonac Harbor at the Trustees Trail site being the most dense (3,000 cells per milliliter). Measurements of total nitrogen across marine sites demonstrated that 13 of the 14 marine locations sampled exceeded the Peconic Estuary Program's recommended value of 0.4 mg N/L on at least one occasion and five sites exceeded the threshold on average: two in Acabonac Harbor, one in Hog Creek, and two in Three Mile Harbor. Spatial surveys with an autonomous surface water vehicle revealed the interactive roles of nitrogen loading and tidal exchange in effecting water quality in Three Mile Harbor, Acabonac Harbor, and Napeague Harbor with water quality near inlets being cooler, saltier, and lower in chlorophyll-a and dissolved oxygen compared to regions further into each system which were generally warmer, had lower salinity, higher chlorophyll-a, and higher dissolved oxygen. Additionally, sediment survey analysis in Napeague Harbor revealed

that sites closer to the mouth of the Harbor and within the western half of the Harbor had coarse grained sediment with lower levels of organic matter, whereas the eastern shoreline had organically enriched muds and fine grain sediment. A fine scale survey in Accabonac Harbor near the Louse Point boat launch identified a small region of fine-grained thick mud, surrounded by a mostly sandy region.

East Hampton Town's freshwater bodies monitored in 2023 displayed a mix of good and poor water quality. Pond Lane, Swan Pond, Wainscott Pond, and Fort Pond experienced blue-green algae blooms at levels that exceeded the NYSDEC threshold warranting closure of the water bodies for varying periods of time. Wainscott Pond was the most consistently impacted system, with every sample exceeding the bloom threshold and mean intensity being nearly an order of magnitude greater than the NYSDEC threshold with the toxin microcystin chronically present but at levels below the EPA guideline for recreation. Fort Pond experienced the densest blue-green algal bloom of 2023 reaching more than 200-times above NYSDEC threshold in early September. On the other hand, Georgica Pond did not experience any blue-green algae blooms but did display low oxygen conditions within its tributaries, Talmage Creek and Georgica Cove. An temporal assessment of Georgica Pond before and after the opening of the cut revealed a dramatic increase in salinity but generally high dissolved oxygen. Collectively, this study revealed regions of East Hampton with excellent water quality, as well as regions requiring remediation as well as further study.

1. Background

Coastal marine ecosystems are amongst the most ecologically and economically productive areas on the planet, providing an estimated US$20 trillion in annual resources or about 43% of the global ecosystem goods and services (Costanza et al., 1997). Approximately 40% of the world's population lives within 100 km of a coastline, making these regions subject to a suite of anthropogenic stressors including intense nutrient loading (Nixon, 1995; de Jonge et al., 2002; Valiela, 2006). Excessive nutrient loading into coastal ecosystems promotes algal productivity and the subsequent microbial consumption of this organic matter reduces oxygen levels and can promote hypoxia (Cloern, 2001; Heisler et al., 2008). The rapid acceleration of nutrient loading to coastal zones in recent decades has contributed to a significant expansion of algal blooms, some of which can be harmful to ecosystems or the humans who live around those ecosystems.

Globally, the phytoplankton communities of many coastal ecosystems have become increasingly dominated by harmful algal blooms (HABs) and New York's coastal waters are a prime example of this trend. Prior to 2006, algal blooms in NY were well-known for their ability to disrupt coastal ecosystem and fisheries but were never considered a human health threat. Since 2006, blooms of the saxitoxin-producing dinoflagellate *Alexandrium fundyense* have led to paralytic shellfish poisoning (PSP)-inducing closures of thousands of acres of shellfish beds in Suffolk County. In 2008, a second toxic dinoflagellate, *Dinophysis acuminata*, began forming large, annual blooms that generated the toxins okadaic acid and DTX-1, both of which are the causative agents of diarrhetic shellfish poisoning (DSP). During the past decade, moderate levels of *Alexandrium* and *Dinophysis* have recently been detected in East Hampton Town waters. The limited nature of sampling, however, has prohibited definitive conclusions regarding the extent and maximal densities of blooms from being established.

In Suffolk County, blooms of the ichthyotoxic dinoflagellate *Cochlodinium* have occurred every year since 2004 in the Peconic Estuary and Shinnecock Bay and bloom water from these regions has been shown to cause rapid morality in fish, shellfish, and shellfish larvae (Gobler et al., 2008; Tang & Gobler, 2009a; 2009b). *Cochlodinium polykrikoides* forms blooms around the world and the highly lethal effects of these blooms on fish, shellfish, shellfish larvae, zooplankton, and subsequent impacts on fisheries have been well established (Kudela & Gobler, 2012). Studies to date suggest short-lived, labile toxins, and reactive oxygen species (ROS) play a central role in the toxicity of *C. polykrikoides* to fish and shellfish (adult, juvenile, and larvae) (Tang & Gobler, 2009a; 2009b). In 2012, these blooms spread into East Hampton Town marine waters. Large populations of bay scallops, that were otherwise abundant prior to the blooms, died following these bloom events (Deborah Barnes, NYSDEC, pers. comm.). However, the precise distribution of *Cochlodinium polykrikoides* blooms in East Hampton Town waters is unknown.

Toxic cyanobacteria blooms represent a serious threat to aquatic ecosystems. Globally, the frequency and intensity of toxic cyanobacteria blooms have increased greatly during the past decade, and have become commonplace in the more freshwater, upper reaches of many US estuaries. Toxin concentrations during many of these blooms often surpass the World Health Organization (WHO) safe drinking water of 1 µg/L and recreational water limit of 20 µg/L (Chorus & Bartram, 1999). There are multitudes of examples of sicknesses and deaths associated with chronic, or even sporadic, consumption of water contaminated with cyanotoxins (O'Neil et al., 2012). Cyanotoxin exposure has been linked to mild and potentially fatal medical conditions in humans including gastrointestinal cancers (i.e., liver, colorectal; Chorus & Bartram, 1999) and more recently, neurological disorders such as Alzheimer's disease (Cox et al., 2005).

Since 2003, the Gobler lab of Stony Brook University has assessed levels of toxic cyanobacteria and microcystin in more than 40 freshwater systems across Suffolk County. Most lakes sampled contain potentially toxic cyanobacteria (typically *Microcystis* spp. or *Anabaena* spp.) and contain detectable levels of the hepatotoxin made by cyanobacteria, microcystin. *Microcystis* is a cyanobacteria that synthesizes a gastrointestinal toxin known as microcystin that is known to inhibit protein phosphorylation. In early September 2012, the NYS Department of Health reported that an autopsy of a dog that died suddenly on the shoreline Georgica Pond revealed *Microcystis*-like cells in its stomach. Although no bloom was obvious in Georgica Pond when it was investigated in late September of 2012, blooms are typically ephemeral, and the most toxic events are typically associated with nearshore, wind accumulated scums, rather than lake water. Historically, the temporal and spatial dynamics of toxic cyanobacteria in Georgica Pond, as well as densities of other harmful algae in East Hampton waters, have not been well-characterized.

A final group of microbes of concern in coastal ecosystems are pathogenic bacteria. Such pathogens can present a hazard to humans recreating in affected waters by infecting the alimentary canal, ears, eyes, nasal cavity, skin, or upper respiratory tract, which can be exposed through immersion or the splashing of water (Thompson et al., 2005). Consumption of contaminated shellfish is one of the most common exposure routes for marine pathogens. Fecal coliform bacteria and *Enterococcus* are the recommended indicator for human pathogens in marine waters, and gastrointestinal symptoms are a frequent health outcome associated with exposure (Thompson et al., 2005). The presence of high levels of fecal coliform bacteria and/or *Enterococcus* may trigger action by a municipal agency to remediate such conditions. One key obstacle to generating a successful remediation plan for high levels of indicator bacteria such as fecal coliform bacteria and/or *Enterococcus* is that the source of the potentially pathogenic bacteria is often unknown. That is, pathogenic, fecal bacteria co-present with fecal coliform bacteria and/or *Enterococcus* may be derived from any animal, including humans and remedial plans for mitigating bacteria from human wastewater will differ radically from plans focused on the mitigation of animal feces. Moreover, mitigation of feces-derived bacteria from birds that live on the waterbody would differ radically from plans to minimize dog or deer feces that might emanate from road run-off.

The objectives of this study were to assess the temporal and spatial dynamics of coliform bacteria, the PSP-causing dinoflagellate *Alexandrium,* the DSP-causing dinoflagellate *Dinophysis*, and the ichthyotoxic dinoflagellate, *Cochlodinium* in East Hampton Town marine waters. It also assesses the dynamics of toxic cyanobacteria and cyanotoxins in East Hampton's major freshwater/brackish bodies. Sampling for general water quality parameters was also included, and sampling proceeded from May through October of 2023 as part of an ongoing monitoring study.

2. Approach

2.1. Water Quality

The 2023 sampling season ran from 9-May-2023 through 12-Octobler-2023. Marine sampling was done on a bi-weekly basis and freshwater sites were sampled weekly. Sampling included fourteen marine sites within Napeague Harbor, Acabonac Harbor, Hog Creek, Three Mile Harbor, and Northwest Creek (Fig. 1; Table 1); and ten freshwater sites within Swan Pond, Pond Lane, Fresh Pond, Hook Pond, Georgica Pond, Wainscott Pond, and Fort Pond (Fig. 1; Table 1). Sampling of Fort Pond, Montauk, was performed by the Concerned Citizens of Montauk and delivered to Southampton for processing.

Each marine water body was sampled from two or three individual sites, with at least one located near the water body's inlet to the Peconic estuary, and the others further from the inlet. Northwest Creek was the exception with only one site located near its inlet. General water quality measurements obtained for each site included salinity, temperature, and dissolved oxygen levels measured with a handheld YSI 556 probe. Onset HOBO data loggers were also deployed at the head of Three Mile Harbor to continuously record bottom temperature and dissolved oxygen levels over time. Additionally, water was collected from sites and analyzed for chlorophyll-a, fecal indicator bacteria, and total Nitrogen. Fecal coliform and *Enterococci* bacteria were quantified using Colilert-18 and Enterolert/Quanti-tray kits according to manufacturer instructions, yielding most probable number (MPN) in terms of colony forming units (CFU) per 100 mL (IDEXX).

The pigment chlorophyll-a, which serves as an analog for algal biomass, was measured by filtering whole water through glass fiber filters, extracting the collected pigment from the filter with acetone, and measuring the fluorescence (Parsons et al., 1984). To assess the abundance of harmful algae, five of these marine sites were sampled more comprehensively with cell counts.

Alexandrium fundyense and *Dinophysis acuminata* are toxic marine dinoflagellates responsible for paralytic shellfish poisoning, and diarrhetic shellfish poisoning (DSP), respectively, and were sampled for during May. For these samples, a concentrated Lugol's sample was taken for each site sieving 1 L of water through a 200 µm mesh and a 20 µm sieve backwashed into a 15 mL centrifuge tube filling the tube to 14 mL (Hattenrath-Lehmann et al., 2013). The harmful "rust tide" dinoflagellate *Cochlodinium*, known for causing fish kills, was monitored from June through October. For *Cochlodinium* samples, whole water was collected and preserved with Lugol's iodine and cells were counted on a Sedgewick-Rafter slide under a microscope.

At the ten freshwater sites (one in Swan Pond, one in Pond Lane, one in Fresh Pond, one in Hook Pond, three in Georgica Pond, one in Wainscott Pond, and two in Fort Pond), samples were collected for the quantification of temperature, salinity, and dissolved oxygen as described above. Blue-green algae fluorescence, an analog for cyanobacterial biomass, was measured using a FluoroProbe with live samples. Samples from Fort Pond, Montauk, were delivered to the lab and measured for fluorescence only.

A telemetry monitoring buoy was deployed in southern Georgica Pond, and uploaded real-time water quality data of temperature, salinity, pH, dissolved oxygen, chlorophyll-a, and blue-green algae fluorescence. The sensors for chlorophyll-a and blue-green algae are not as sensitive as the discreet sampling methods, but displayed trends that parallel those measurements.

2.2. Indicator bacteria quantification

During the present study, fecal bacteria contamination was assessed at four sites within Acabonac and five sites within Three Mile Harbors on selected dates spanning from May to October 2023. On each date, surface water (0.25 m depth) samples were collected in sterile 2 L bottles and transported on ice to the laboratory for further processing within two hours of collection. Triplicate whole water samples were collected for DNA analysis in which samples were well-mixed to ensure even distribution of biomass prior to filtering 25 – 100 mL onto a 0.2 µm Millipore polycarbonate filter, depending on water turbidity. Samples were immediately frozen in liquid nitrogen and stored at -80°C until further processing. In parallel, sites were additionally sampled for fecal coliform bacteria and *Enterococci* bacteria from May through October, quantified using the IDEXX Enterolert & Quanti-Tray/2000 sampling kits, giving MPN per 100mL.

2.3. *HYCAT surveys*

During September and October 2023, a HYCAT surface autonomous vehicle (SAV) (Fig. 2) was deployed to Napeague Harbor, Acabonac Harbor, and Three Mile Harbor. The HYCAT SAV was equipped with a YSI EXO2 to provide fine-level spatial resolution of various water quality parameters, including temperature, salinity, dissolved oxygen, pH, and chlorophyll-a.

2.4. *Sediment surveys*

During the present study, sediment samples were amassed from 10 locations in Acabonac Harbor concentrating near the Louse Point boat launch and 39 locations across Napeague Harbor. Samples were weighed and measured to quantify sediment type, the overall thickness of muds, macrophyte abundance, and estimated sediment nutrient flux.

3. Findings – Marine Systems

3.1. General Water Quality: Temperature, Salinity & Dissolved Oxygen

Overall average temperatures averaged 21.7°C and ranged 21.3 – 22.8°C across East Hampton's marine sites, while summer (5-July-2023 to 12-September-2023) averages ranged 24.1 – 27.1°C and averaged 25.3 °C (Fig. 3). Maximum surface temperatures in East Hampton ranged

24.5 – 28.4°C and averaged 26.6°C (Fig. 3). Average summer and maximum salinities in East Hampton ranged 23.2 – 27.7 PSU and 27.8 – 29.9 PSU, respectively, and averaged 26.5 PSU and 28.9 PSU, respectively (Fig. 4). Overall average salinity ranged 22.5 – 28.4 PSU and averaged 26.9 PSU across East Hampton's marine sites. Summer averages ranged 23.2 – 28.1 PSU (Fig.)4. Overall average dissolved oxygen (DO) concentrations ranged 6.9 – 9.9 mg/L and averaged 8.1 mg/L, while summer average concentrations ranged 6.5 – 10.6 mg/L and averaged 7.8 mg/L (Fig. 5). Minimum surface DO concentrations in East Hampton ranged 4.2 – 8.1 mg/L and averaged 6.3 mg/L (Fig. 5). Overall and summer average DO concentrations were generally above the NYSDEC minimum standard for DO (4.8 mg/L).

Surface water temperature and DO were measured continuously in Three Mile Harbor (EH11) during summer 2023. In Three Mile Harbor, temperature from the end of May until the end of October ranged 17.0 – 27.0°C and average 22.3°C (Fig. 6). During that time, DO concentrations ranged 0.0 – 8.4 mg/L and averaged 1.9 mg/L. Throughout the sampling season, dissolved oxygen concentrations in Three Mile Harbor deviated below the NYSDEC minimum for DO, with all DO levels in September and October below the NYSDEC DO minimum (Fig. 7).

3.2. Nitrogen and Eutrophication

In Napeague Harbor, total N concentrations ranged 0.19 – 0.60 mg N/L on all dates during 2023 between both sites EH1 and EH2 (Fig. 8). On 12-September-2023, concentrations exceeded Peconic Estuary Program threshold for EH1 with a value of 0.54 mg N/L (Fig. 9). On 19-July-2023 and 16-August-2023 concentrations exceeded the threshold for EH2 with values of 0.60 mg N/L and 0.41 mg N/L, respectively (Fig. 9). In Acabonac Harbor, total N concentrations ranged 0.19 – 11.1 mg N/L throughout 2023 (Fig. 8). In this region, notable concentrations that exceeded the Peconic Estuary Program threshold were on 19-July-2023 and 16-August-2023 at EH6a and EH7a, respectively, in which concentrations were 0.93 and 0.99 mg N/L, respectively (Fig. 10). At EH6a, total N concentrations exceeded the threshold throughout the whole monitoring period. At Northwest Creek, concentrations ranged 0.22 – 0.67 mg N/L throughout 2023 and were exceeded the Peconic Estuary Program total N threshold once on 19-July-2023 (Fig. 8; Fig. 13). In Three Mile Harbor, concentrations ranged 0.17 – 0.80 mg N/L (Fig. 8). At EH11, it had the highest concentration of all the sites on 16-August-2023 at 0.80 mg N/L (Fig. 12).

The overall average concentration throughout the sites ranged from 0.27 – 0.66 mg N/L (Fig. 8). The summer average ranged from 0.01 – 0.75 mg N/L. The maximum ranged from 0.36 – 0.99 mg N/L (Fig. 8).

3.3. Algae and Harmful Algae; Dinophysis, Cochlodinium, & Alexandrium

All algae contain the pigment chlorophyll-a and therefore, is measured as a proxy for total phytoplankton biomass. Moderate levels of algae support productive fisheries and ecosystems, but excessive algal growth can lead to a series of negative ecological consequences, including hypoxia and acidification, and could be a sign of the development of an algal bloom.

Overall average chlorophyll-a concentrations ranged 3.7 – 17.9 µg/L and averaged 8.1 µg/L (Fig. 14). Summertime average chlorophyll-a concentrations ranged 4.3 – 22.2 µg/L and averaged 10.3 µg/L (Fig. 14). Maximum chlorophyll-a concentrations were, on average, 20.8 µg/L across all sites and ranged 5.9 – 66.4 µg/L (Fig. 14). The USEPA considers 20 µg/L of chlorophyll-a in marine waters as eutrophic. In this season, maximum concentrations in Acabonac Harbor (EH6 and EH7a), Hog Creek (EH9), and Three Mile Harbor (EH11 and EH11a) exceeded this level (Fig. 14). For the entirety of May through the end of July, chlorophyll-a concentrations remained below the USEPA maximum chlorophyll-a level (Fig. 15). Chlorophyll-a concentrations generally exceeded the USEPA maximum in late July through late August. In Acabonac Harbor (EH7a), had concentrations above the USEPA maximum in August at 30.8 and 66.4 µg/L (Fig. 15). In Hog Creek (EH9), chlorophyll-a concentration exceeded the USEPA maximum on 16-August-2023 at 51.3 µg/L (Fig. 15).

Alexandrium is a toxic dinoflagellate that synthesizes saxitoxin, which leads to the syndrome of PSP, and can cause illness or death in individuals consuming shellfish containing these toxins (Anderson, 1997). PSP has been occurring annually in New York waters since it first appeared in 2006, with Sag Harbor being the closest region to East Hampton experiencing a shellfish beds closure due to these. In 2013, densities of *Alexandrium* exceeded 1,000 cells/L, levels known to cause toxicity in shellfish (Anderson, 1997). There was a high of 3,444 cells/L of *Alexandrium* in Three Mile Harbor (EH11) on 3-April-2023, exceeding the bloom threshold (Fig. 16).

Dinophysis was present in East Hampton waters during 2023, albeit very sparsely across the surveying season. In Napeague Harbor (EH1), it was 9 cells/L and 7 cells/L on 6-June-2023 and 20-June-2023, respectively (Fig. 17). At Acabonac Harbor (EH7a), *Dinophysis* was only present on 5-July2023 at 28 cells/L (Fig. 18). In Three Mile Harbor (EH11), *Dinophysis* had the highest density of 7,056 cells/L on 5-June-2023 (Fig. 16). At Hog Creek (EH9), the alga was present at very low concentrations throughout the monitoring period ranging from 2 – 56 cells/L (Fig. 19). In Northwest Creek (EH13), *Dinophysis* was present at a high of 588 cells/L on 5-July-2023 (Fig. 20). *Dinophysis* concentrations never exceeded the bloom threshold for *Dinophysis* (10,000 cells/L) during 2023.

Cochlodinium is an ichthyotoxic dinoflagellate that has caused fish kills across the globe including some sites on eastern Long Island (Kudela & Gobler, 2012). *Cochlodinium* blooms more than 300 cells/mL have been known to cause mortality in larval fish, which use these estuarine systems as nurseries, and in shellfish (Tang & Gobler, 2009a; 2009b). At Nagpeague Harbor (EH1), it was 604 cells/mL and at Acabonac Harbor (EH7a) it was 2,866 cells/mL (Fig. 22; Fig. 23). In Hog Creek (EH9), *Cochlodinium* exceeded the bloom threshold on 16-August-2023 at 866 cells/mL (Fig. 24). In Three Mile Harbor (EH11) and Northwest Creek (EH13), concentrations did not exceed the threshold. Three Mile Harbor had a high of 178 cells/mL on 1-August-20 (Fig. 25). Northwest Creek (EH13) had a high of 50 cells/mL on 16-August-2023 (Fig. 26). The distribution and intensity of *Cochlodinium* blooms differ from year-to-year, highlighting the importance of long-term monitoring of water quality trends. It is notable that although *Cochlodinium* does not bloom consistently in each individual location from year to year, it has spread to and reached harmful densities in several harbors. Given its ability to form cysts (Tang & Gobler, 2012), this finding suggests the potential to spread and bloom in more locations in the future.

3.4. Fecal Coliform Bacteria and Enterococcus

Fecal coliform concentrations varied among sites in Acabonac Harbor and Three Mile Harbor during summer and fall 2023. In Acabonac Harbor, concentrations at EH5 ranged from 2.0 – 203.8 colony forming units (CFU) per 100 mL for summer through fall (Fig. 27). At EH6a, concentrations ranged 6.2 – >401 CFU per 100 mL with 19-July-2023 being the highest concentration, which exceeds the NYSDEC maximum of 14 CFU per 100 mL (Fig. 27). Sites EH7a and EH7b had lower concentrations compared to the other two sites with EH7b having the highest concentration on 12-September-2023 at 198.2 CFU per 100 mL (Fig. 27). In Three Mile Harbor, concentrations at EH11a exceeded the NYSDEC maximum throughout the whole monitoring period (Fig. 27). EH11a had concentrations ranging from 71.8 – >401 CFU per 100 mL. Concentrations at EH10 ranged <2.0 to 25.0 CFU per 100 mL, but only exceeded the maximum on 12-Sepctember-2023 (Fig. 27). At EH10a, concentrations ranged from <2.0 – 48.6 CFU per 100 mL (Fig. 27). At EH11, the most notable day was 19-July-2023 with a concentration of 111.2 CFU per 100 mL (Fig. 27). At EH12, concentrations ranged from 6.0 – 57.0 CFU per 100 mL (Fig. 27). Fecal coliform concentrations exceeded the USFDA and NYSDEC shellfishing standards at EH11a most frequently throughout summer and fall 2023 (Fig. 27).

Importantly, the National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish (USFDA, 2017) requires 30 data points for an official evaluation of water quality to be considered for shell fishing, which this study now cumulatively exceeds over the past several years. Moreover, it requires highly precise standards (geometric mean & estimated 90th percentile value) for the type of sampling regimen used and method of examining samples (mean probably number vs. filters). The data provided within this report is meant to provide general information on fecal coliform and to assist in guiding future sampling by NYSDEC who have ultimate authority with regards to shellfish sanitation in NY.

Enterococcus bacteria were also quantified for sites in Acabonac Harbor and Three Mile Harbor as well, which was used by the NYSDOH as an environmental standard for bathing beaches. During July 2023, enterococci concentrations were all above NYSDOH maximum concentration at all Acabonac Harbor sites. At sites EH5, EH6a, EH7a, and EH7b, all had concentrations >401 CFU per 100 mL on 19-July-2023 (Fig. 28). At EH5, concentrations ranged from <2.0 – >401 CFU per 100 mL from May through October (Fig. 28). At EH6a, concentrations ranged 12.4 – >401 CFU per 100 mL from June through October (Fig. 28). At EH7b, concentrations ranged from 8.2 – >401 CFU per 100 mL (Fig. 28). In Three Mile Harbor, enterococci concentrations varied by site. In EH10, all concentrations were below both NYSDOH standards throughout the monitoring period and ranged from 2.0 – 41.8 CFU per 100 mL for June through October (Fig. 28). At the EH10a site, concentrations ranged 2.0 – 159.0 CFU per 100 mL (Fig. 28). At EH11, concentrations were all below the NYSDOH maximum and ranged from <2.0 – 89.6 CFU per 100 mL during May through October (Fig. 28). At the EH11a site, concentrations were >401 CFU per 100 mL on 19-July-2023 and ranged 2.0 – >401 CFU per 100 ml from May to October, with the higher concentration exceeding the NYSDOH shellfishing standard during the summer months (Fig. 28). Lastly, at EH12, concentrations were >401 CFU per 100 mL on 16-

August-2023, exceeding NYSDOH maximum, and ranged 6.0 – >401 CFU per 100 mL throughout the summer and fall of 2023 (Fig. 28).

3.5 Microbial Source Tracking

For 2023, microbial source tracking was utilized to assess the relative abundance of four classes of fecal bacteria in Acabonac Harbor and Three Mile Harbor. The use of digital PCR permits the quantification of bacteria specifically emanating from humans, deer, birds, and dogs or small mammals. Within Acabonac Harbor, birds and dogs/small mammals were the biggest source of fecal bacteria throughout all the sites in the summer (Fig. 29). Two sites in Acabonac Harbor, EH6a and EH7b, had traces of human fecal bacteria during the summer (Fig. 29). Human bacteria were found in one site in Three Mile Harbor, EH10 (Fig. 29). Bird bacteria was also found at all the sites in Acabonac Harbor and Three Mile Harbor in the summer (Fig. 29). Enterococcus bacteria was detected at all the sites in Acabonac Harbor and Three Mile Harbor (Fig. 30). Site EH6a in Acabonac Harbor and site EH11a in Three Mile Harbor had the most abundant detected out of all the sites (Fig. 30).

Throughout the summer there was a consistent detection of dog/small animal bacteria detected, with the highest in Acabonac Harbor, site EH6a, on 19-July-2023 (Fig. 31). In comparison, at site EH12 on 12-September-2023 the highest dog/small mammal fecal bacteria were detected, but not as high as at EH6a (Fig. 31). On two dates, 19-July-2023 and 16-August-2023, in Acabonac Harbor at site EH7b (Fig. 31). Human fecal bacteria was detected on 12-September-2023 at in Acabonac Harbor at EH6a (Fig. 31). At site EH7b in Acabonac Harbor, human fecal bacteria were detected on 19-July-2023 and 16-August-2023 (Fig. 31). Bird fecal bacteria was consistently detected throughout all the sites and at almost all the dates (Fig. 31). Enterococcus bacteria was detected almost throughout the whole monitoring period at both Acabonac Harbor and Three Mile Harbor (Fig. 32). On 19-July-2023, enterococcus bacteria was at its highest at Acabonac Harbor at site EH6a (Fig. 32). At Three Mile Harbor site EH11a, enterococcus bacteria were at its highest on 12-September-2023.

The highest percentage class of fecal bacteria was dog/small mammal consisting over 50% detection at almost all the sites in Acabonac Harbor and Three Mile Harbor (Fig. 33). In this monitoring period’s case, the human fecal bacteria signal was too small for meaningful comparisons to be made (1-2%) (Fig. 33). Overall, there were less human fecal bacteria detected and a more significant dog/small mammal detection than birds.

3.6 Sediment surveys

For 2023, sediment surveying was utilized to compare sediment characteristics in Acabonac Harbor and Napeague Harbor. Measuring % mass through filtration and dry weight measurements allows the quantification of sediment quality, spread, and % organic matter. Within the 10 sites sampled in Acabonac Harbor, mud depth ranged from 0.0 – 1.75 m, with the deepest section in AC8 (Fig. 34). Organic matter between the ten sites ranged from 0.5 – 8.8% (Fig. 37). In the interpolated graph, the % organic matter increases as one goes closer to shore (Fig. 38). Site AC6, which is in the middle of the surrounding sites, had the largest % organic matter of 8.8% (Fig. 37). AC10, the site closest to the shore, had the lowest % organic matter of 0.5% (Fig. 37). Sediment quality at Acabonac Harbor ranged from black mud to muddy sand (Fig. 40). Sites AC6 and AC8 were the only sites that had black mud. The % by weight of sediment <90 µm ranged from 2.89 – 55.08% (Fig. 41). Site AC8, had the greatest percentage, 55.08%, of sediment <90 µm (Fig. 41). Interpolated graphs show that the % by weight of <90 µm sediment increases closer to shore (Fig. 42).

Napeague Harbor had 39 sites sampled, with depths ranging from 0.0 – >0.7 m (Fig. 44). Eight of the eastern sites had depths greater than 0.7m (Fig. 44). The % organic matter across these sites ranged from 0.00 – 6.99% (Fig. 47). Sites west and closest to the inlet had very low % organic matter, while sites to the east had the highest % organic matter, based on the interpolated graphs (Fig. 48). Sediment quality had a larger range from black mud to rock/shell (Fig. 50). Only one site closest to the inlet had rock/shell sediment. Easterly sites had sediment quality consisting mostly of mud (Fig. 50). Southern sites had mostly sand and muddy sand (Fig. 50). The % by weight of sediment <90 µm ranged from 0.00 – 93.46% (Fig. 51). Similarly to % organic matter, the eastern sites had the highest % by weight of sediment <90 µm and the western sites had the lowest (Fig. 51; Fig. 52).

3.7. HYCAT surveys

In Acabonac Harbor, the HYCAT survey showed that temperature, salinity, DO, and chlorophyll-a varied by location within the harbor. The lowest temperatures (<18.5°C) were reported within the western portion of the harbor, while the highest temperatures (>19.3°C) were to the northeastern portion of the harbor (Fig. 54). To the north and south of the inlet, temperatures were generally 18.7 – 18.9°C (Fig. 54). The highest measurements of salinity (>29.2 PSU) occurred in the inlet and towards the northwest of the inlet (Fig. 55). The lowest salinity values (<25.0 PSU) occurred in the areas to the south and west of the inlet (Fig. 55). DO concentrations were highest (>9.2 mg/L) at the mouth of the inlet and was lowest at the west of the harbor (<7.7 mg/L) (Fig. 56). Chlorophyll-a concentrations were lowest (<0.15 μg/L) in areas west of the harbor (Fig. 57). Concentrations increased above 0.25 μg/L in the areas south of the inlet.

In Three Mile Harbor, temperatures were lowest (<21.2°C) in the middle of the harbor. However, temperature was highest (>22.4°C) in the south of the harbor (Fig. 58). Salinity was high (>29.4 PSU) across the entire (Fig. 59). South of the marina closest inland, salinity was at its lowest, <25.0 PSU (Fig. 59). DO concentrations were <7.8 mg/L at the western side of the harbor and were high (>10.8 mg/L) at the south of the harbor (Fig. 60). Chlorophyll-a concentrations were lowest (<2.50 μg/L) north of the harbor and was highest at the south of the harbor (>12.46 μg/L) (Fig. 61).

In Napeague Harbor, the HYCAT surveyed temperature, salinity, DO, and chlorophyll-a at both high and low tide. Temperatures were highest (>21.3°C) in the southwestern section of the harbor during high tide, while temperature was the highest at the south of the harbor (>20.1°C) (Fig. 62). At high tide, the lowest temperature was at the southeastern side (<20.5°C), while during low tide it was in the middle and upper east of the harbor(<19.6°C) (Fig. 62). Salinity levels in Napeague Harbor was highest closest to Napeague Bay at high tide (>29.9 PSU), while during low tide it was highest on the northern and southeastern parts of the harbor (>29.9 PSU) (Fig. 63). Salinity was lowest at the southwestern part of the harbor at high tide (<29.4 PSU), while it was lowest in the middle during low tide (<29.6 PSU) (Fig. 63). Dissolved oxygen concentrations were highest at the mouth (>9.0 mg/L) during high tide, and highest at the south (>8.0 mg/L) during low tide (Fig. 64). At high tide, the lowest was at the southeastern part of the harbor (<8.1 mg/L), while at low tide north and southeastern parts had the lowest (<7.4 mg/L) (Fig. 64). Chlorophyll-a concentrations were highest south of the harbor during high tide (>5.8 μg/L) (Fig. 65). During low tide, the highest Chlorophyll-a concentrations were at the south and most of the middle (>5.9 μg/L), while it was lowest on the north (<2.7 μg/L) (Fig. 65). During high tide, it was lowest at the mouth and again at the south part of the harbor (<1.4 μg/L) (Fig. 65).

4. Findings - Freshwater Systems

4.1. General Water Quality: Temperature, Salinity & Dissolved Oxygen

The overall average temperature across East Hampton's freshwater sites was 23.0°C and ranged 18.3 – 26.1°C, while summertime average temperature was 26.1°C and ranged 20.2 – 29.3°C (Fig. 66). Maximum temperature was, on average, 28.8°C and ranged 21.9 – 30.9°C (Fig. 66). At the buoy in Georgica Pond, temperature was, on average, 20.9°C and ranged 3.1 – 30.9°C (Fig. 67). Temperature did not appear to be affected by the opening of the ocean inlet to the south of Georgica Pond at the beginning of October (Fig. 67). Overall average salinity for the freshwater sites was 5.5 PSU and ranged 0.03 – 23.1 PSU, while summer average salinity was 5.0 PSU and ranged 0.04 – 21.9 PSU (Fig. 68). Maximum salinity was, on average, 10.2 PSU and ranged 0.09 – 29.2 PSU (Fig. 68). At the buoy in Georgica Pond, prior to the opening of the ocean inlet to the south of the waterbody, salinity was, on average, 8.5 PSU and ranged 6.2 – 10.9 PSU (Fig. 69). After the inlet was opened, salinity rapidly increased, but was not recorded because of the sensor malfunction (Fig. 69). However, the data did show the increase of salinity to 28.3 on 16-October-2023. The overall average dissolved oxygen (DO) average was 7.8 mg/L and ranged 6.1 – 11.0 mg/L, while summer average concentrations were 6.8 mg/L and ranged 4.8 – 9.4 mg/L (Fig. 70). Minimum DO was, on average, 3.6 mg/L and ranged 0.2 – 6.48 mg/L.

In Pond Lane (PLEH), DO was, on average, 7.8 mg/L and was above the NYSDEC minimum for DO except for one day on 31-August-2023 at 0.7 mg/L (Fig. 70; Fig. 71). In Swan Pond (SPEH), DO averaged 6.1 mg/L and was above NYSDEC minimum for DO except for one day on 31-August-2023 at 0.2 mg/L (Fig 70; Fig. 72). In Fresh Pond (EH4), DO was, on average, 7.2 mg/L and fell above the NYSDEC minimum for DO (4.8 mg/L) throughout the monitoring period (Fig. 70; Fig. 73). In Wainscott Pond (WPS), DO concentrations were, on average, 11.1 mg/L, and ranged 6.6 – 16.9 mg/L, never once falling below the NYSDEC minimum for DO (Fig. 70; Fig. 74). In Hook Pond (EH17), all DO concentrations fell above the NYSDEC minimum for DO. The average was 8.7 mg/L and ranged 5.9 – 12.0 mg/L (Fig. 70; Fig. 78). All three sites at Georgica Pond had varied DO concentrations and had frequent concentrations that exceeded the NYSDEC minimum. EH15 had an average of 5.7 mg/L and ranged 1.5 – 10.0 mg/L (Fig. 70; Fig. 75). At EH16b the average DO was 7.0 mg/L and ranged from 2.46 – 18.33 mg/L (Fig. 70; Fig. 76). At EH18 concentrations exceeded the NYSDEC minimum throughout the entire monitoring period, with an average of 8.6 mg/L and a range from 5.3 – 16.3 mg/L (Fig. 70; Fig. 77). At the buoy in Georgica Pond, DO was, on average, 8.3 mg/L and ranged 3.9 – 12.0 mg/L, falling below the NYSDEC minimum for DO multiple times at the end of summer through autumn (Fig. 79). Note that there was a period from 25-September-2023 to 16-October-2023 where the sensors at the Georgica Pond buoy was down, so no data for temperature, dissolved oxygen, or salinity were collected during this time.

4.2. Nitrogen and Eutrophication

Fresh Pond (EH4) was the only freshwater site sampled for total nitrogen. Concentrations ranged 0.41 – 0.83 mg N/L during 2023, with concentrations exceeding the Peconic Estuary Program total N threshold (0.40 mg N/L) for all dates during 2023 (Fig. 80). Overall average and summer average total N concentration were 0.67 mg N/L and 0.75 mg N/L, respectively, both of which were above the Peconic Estuary total N threshold (Fig. 80).

4.3. Algae and Harmful Algae; Cyanobacteria

Total algal biomass for freshwater systems was measured using a BBE Moldaenke Fluoroprobe. These values tend to be higher than traditional chlorophyll-a extraction. The overall average of chlorophyll-a concentration at freshwater sites in East Hampton was 100.8 µg/L and ranged 13.8 – 266.4 µg/L, while summertime average concentration was 93.9 µg/L and ranged 12.3 – 97.6 µg/L (Fig. 81). Maximum chlorophyll-a concentration was, on average, 660.8 µg/L and ranged 46.99 – 3974.4 µg/L (Fig. 81). The overall average, summertime average, and maximum for chlorophyll-a at all sites exceeded the USEPA maximum chlorophyll-a concentration for eutrophic freshwater systems (8 µg/L) (Fig. 81). In Pond Lane and Swan Pond, average concentrations were 33.0 and 264.6 µg/L, respectively, and ranged 12.6 – 86.5 µg/L and 27.1 – 1144 µg/L, respectively (Fig. 82; Fig. 83). In Fresh Pond, the average concentrations were 26.4 µg/L and ranged 12.8 – 55.1 µg/L (Fig. 84). In Hook Pond, average concentrations were 32.0 µg/L and ranged 4.8 – 69.1 µg/L (Fig. 89). On 3-August-2023, the chlorophyll-a concentrations was below the USEPA maximum for chlorophyll-a in freshwater systems at 4.8 µg/L (Fig. 89). In Georgica Pond, chlorophyll-a concentrations were, on average, 13.8 µg/L, 55.8 µg/L, and 18.5 µg/L at sites EH15, EH16, and EH18, respectively, and ranged 2.7 – 51.4 µg/L, 1.4 – 595.3 µg/L, and 4.8 – 60.2 µg/L, respectively (Fig. 81). In Wainscott Pond, concentrations were, on average, 266.4 µg/L and ranged 121.7 – 525.0 µg/L, with concentrations on all dates exceeding the USEPA maximum for chlorophyll-a in freshwater systems (Fig. 85). In Fort Pond, concentrations were, on average, 32.6 µg/L and 265 µg/L for the north and south sites, respectively, and ranged 18.6 – 47.0 µg/L and 26.2 – 3974.4 µg/L, respectively, with concentrations on all dates exceeding the USEPA maximum for chlorophyll-a in freshwater systems (Fig. 81). In Fort Pond South, it had the most notable chlorophyll-a concentration of 3974.4 µg/L on 6-September-2023 (Fig. 91). Chlorophyll-a concentrations at the Georgica Pond buoy was, on average, 6.0 µg/L and ranged 0.9 – 546.2 µg/L (Fig. 92). Chlorophyll-a concentrations were for the most part stable throughout the monitoring period, with scatters of high concentrations between August and October.

Toxic cyanobacteria blooms represent a serious threat to aquatic ecosystems and human health. Whereas chlorophyll-a is an analog for algal biomass, blue-green algal fluorescence serves as an analog specifically for cyanobacterial biomass. The recreational safety limit of 25 µg/L used by the NYSDEC was surpassed in Pond Lane, Swan Pond, Wainscott Pond, and Fort Pond South, in 2023. The overall average concentration of blue-green algae across freshwater sites in East Hampton was 53.6 µg/L and ranged 0.21 – 186.8 µg/L, while the summertime average was 58.3 µg/L and ranged 0.41 – 191.8 µg/L (Fig. 93; Fig. 94). Maximum blue-green algae levels were, on average 499.1 µg/L and ranged 2.4 – 3973.5 µg/L (Fig. 93; Fig. 94). In Pond Lane, the average blue-green concentration was 7.4 µg/L and ranged 0.0 – 32.6 µg/L and did not start being detected until 5-July-2023 (Fig. 95). In Swan Pond, average concentration was 62.0 µg/L and ranged 0.0 – 483.5 µg/L (Fig. 96). Blue-green algae was detected opposite of Pond Lane, as it was detected early in the monitoring period at high concentrations and was nearly gone by September. Fresh Pond had very low concentrations of blue-green algae throughout the entire monitoring period with a high of 2.4 µg/L on 16-August-2023 (Fig. 97). In Hook Pond, blue-green algae levels were also relatively low with an average of 1.7 µg/L with the highest concentration on 20-July-2023 at 5.95 µg/L (Fig. 99). In Georgica Pond, at sites EH15, EH16b, and EH18, blue-green algae concentrations were on average 0.5 µg/L, 1.4 µg/L, and 4.0 µg/L, respectively, and ranged 0.0 – 2.54 µg/L, 0.0 – 3.96 µg/L, and 0.0 – 11.3 µg/L, respectively (Fig. 99; Fig. 100; Fig. 101). In EH15, EH16b and EH18, blue-green algae concentrations never exceeded the NYSDEC bloom threshold. In Wainscott Pond, blue-green algae concentrations exceeded the NYSDEC bloom threshold throughout the whole monitoring period and was on average, 183.9 µg/L and ranged 43.4 – 453.9 µg/L (Fig. 98). In Fort Pond, at the north and south sites, blue-green algae levels were, on average, 11.1 µg/L and 245.3 µg/L, respectively, and ranged 0.0 – 20.96 µg/L and 0.2 –

3973.5 µg/L, respectively (Fig. 100; Fig. 101)). The most notable bloom was on 6-September-2023 in Fort Pond South at 3973.5 µg/L (Fig. 101).

Regarding cyanotoxins in freshwater sites, concentrations of microcystin varied by site. Microcystin concentration at Pond Lane was measured on only one date on 31-August-2023 at 0.31 µg/L (Table. 3). Swan Pond had detectable levels on 23-May-2023 and 6-June-2023, at 0.23 µg/L and 0.26 µg/L, respectively (Table. 3). At Fort Pond South there were detectable values on 6-September-2023 and 12-September-2023 at 2.94 µg/L and 0.37 µg/L, respectively, exceeding the drinking water threshold of 0.3 µg/L (Table. 3). At sites in Georgica Pond and Fort Pond North, all microcystin concentrations were <0.15 µg/L (Table. 3). In Wainscott Pond, microcystin levels were the most frequently detected in 2023, but all at very low concentrations, however exceeded the drinking water threshold three consecutive week from 11-October-2023 to 25-October-2023 (Fig. 105). At no point during the monitoring period was microcystin present to exceed the recreation threshold of 8 µg/L in freshwater systems. At Fresh Pond, Hook Pond, and the three sites in Georgica Pond no cyanobacteria were identified (Table. 2). The most common cyanobacteria found at all sites except for Wainscott Pond was Planktothrix. Wainscott Pond had a more diverse assortment of cyanobacteria identified (Table. 2).

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Figures and Tables

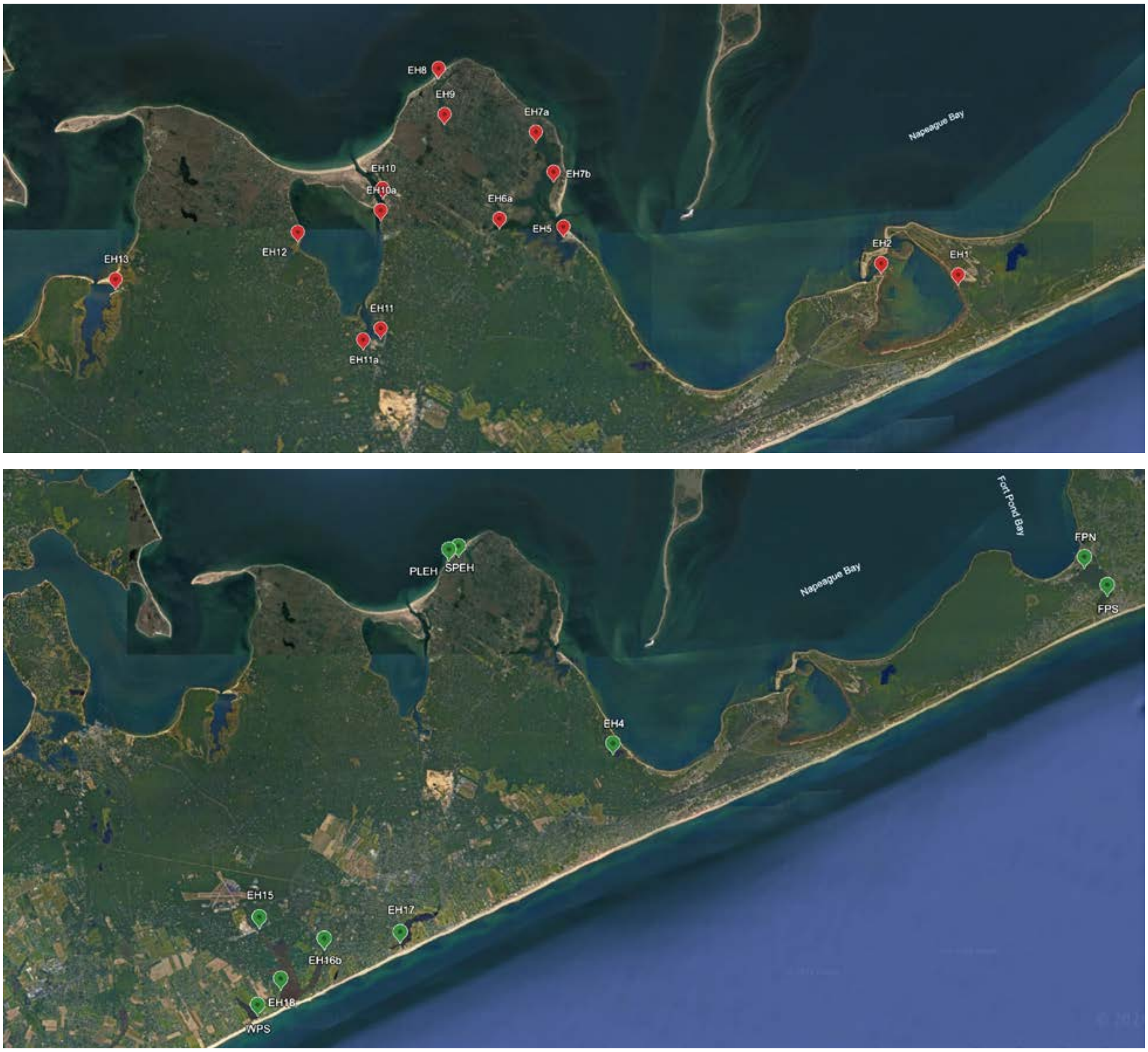


Figure 1. Map of the various marine (top, red) and freshwater (bottom, green) sampling sites in East Hampton, NY during 2023.

Table 1. List of the East Hampton sampling sites in 2023, sites shaded in red and green represent marine and freshwater sites, respectively.

Waterbody	Location	Abbr.	Coordinates
Napeague Harbor	Napeague Harbor Rd. Lazy Pt.	EH1 EH2	41.01079, -72.03769 41.01291, -72.05687
Acabonac Harbor	Louse Pt. Ramp Shipyard Ln. Trustees Trail Gerald Dr.	EH5 EH6a EH7a EH7b	41.01982, -72.13599 41.02133, -72.15191 41.03760, -72.14284 41.03011, -72.13845
Hog Creek	Kings Point Rd. 29 Isle of Wight Rd.	EH8 EH9	41.04956, -72.16711 41.04090, -72.16559
Three Mile Harbor	Gann Rd. Squaw Rd. Head of the Harbor Soak Hides Preserve Hands Creek Rd.	EH10 EH10a EH11 EH11a EH12	41.02701, -72.18102 41.02289, -72.18149 41.00072, -72.18148 40.99860, -72.18582 41.01880, -72.20211
Northwest Creek	NW Landing Rd.	EH13	41.00991, -72.24753
Swan Pond, East Hampton	Swan Pond	SPEH	41.04625, -72.17805
Pond Lane, East Hampton	Pond Lane	PLEH	41/0537, -72.17411
Fresh Pond, Amagansett	Fresh Pond	EH4	40.99510, -72.11771
Hook Pond	Hook Pond	EH17	40.94619, -72.19077
Georgica Pond	Rt. 27 Cove Hollow Rd. 4 Eel Cove Rd.	EH15 EH16b EH18	40.94999, -72.23915 40.94450, -72.21686 40.93408, -72.23182
Wainscott Pond	Wainscott Pond, South	WPS	40.92729, -72.23973
Fort Pond	North South	FPN FPS	41.04331, -71.95556 41.03603, -71.94773

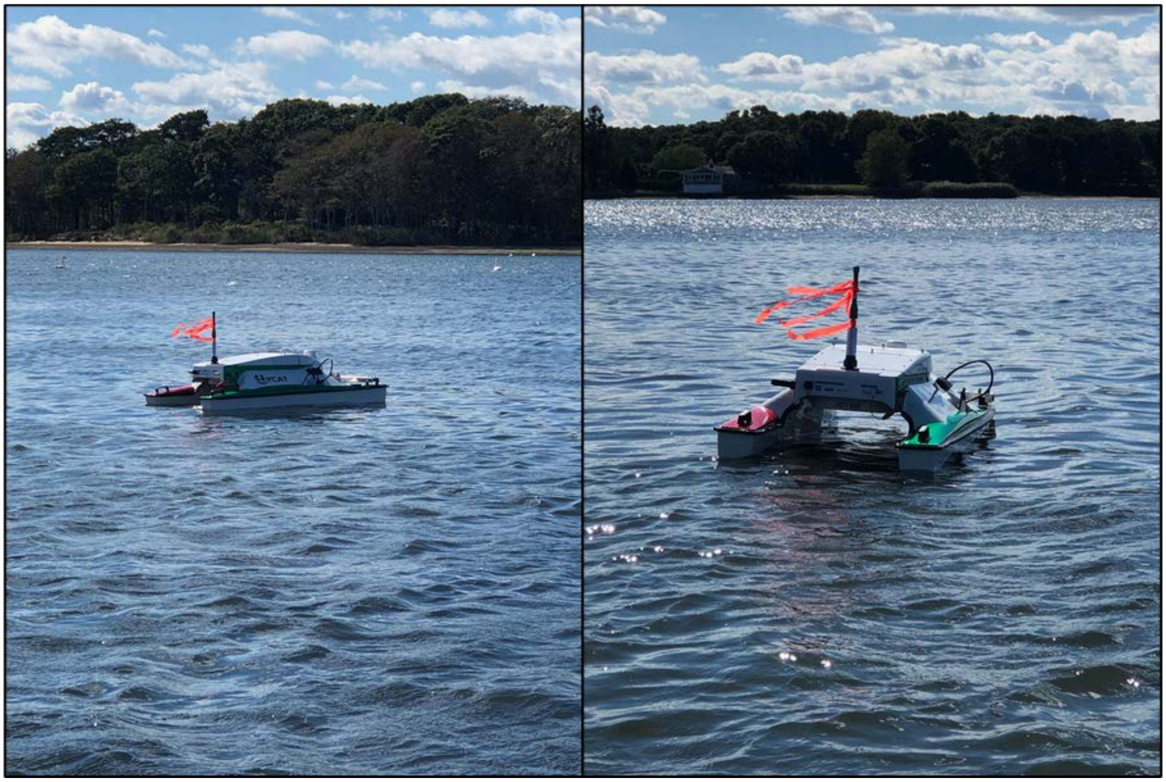


Figure 2. Images of the HYCAT autonomous surface vehicle used in surveys of Acabonac Harbor, Napeague Harbor and Three Mile Harbor between September and October 2023.

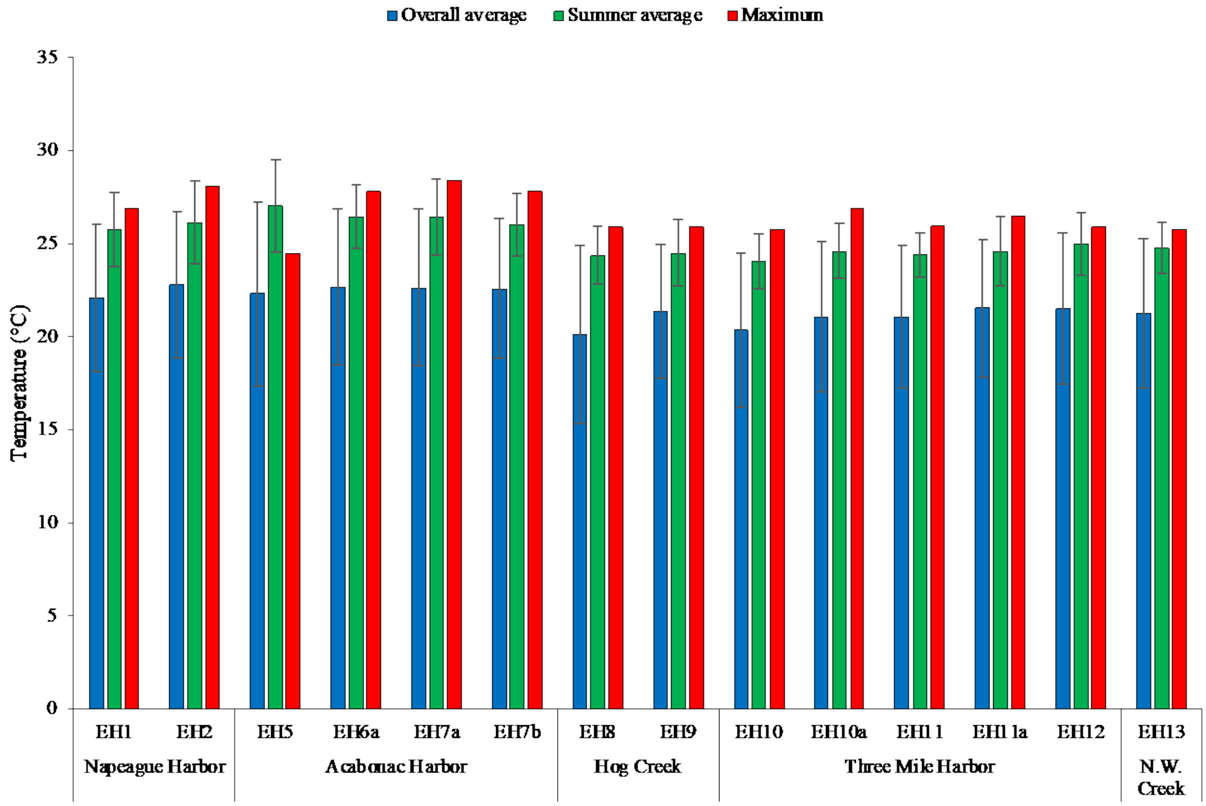


Figure 3. Overall average, summer average, and maximum surface water temperatures (°C) at various marine sites in East Hampton during 2023. Error bars represent standard deviation. N.W. Creek = Northwest Creek.

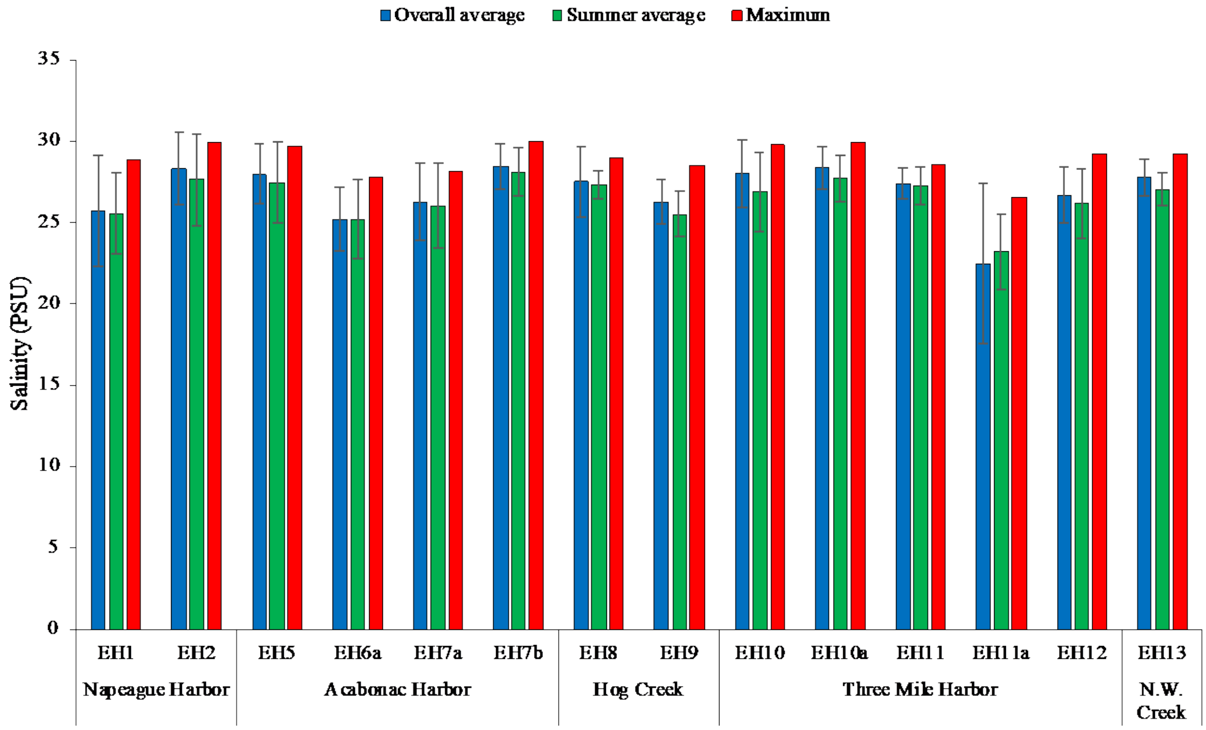


Figure 4. Overall average, summer average, and maximum surface water salinities (PSU) at various marine sites in East Hampton during 2023. Error bars represent standard deviation. N.W. Creek = Northwest Creek.

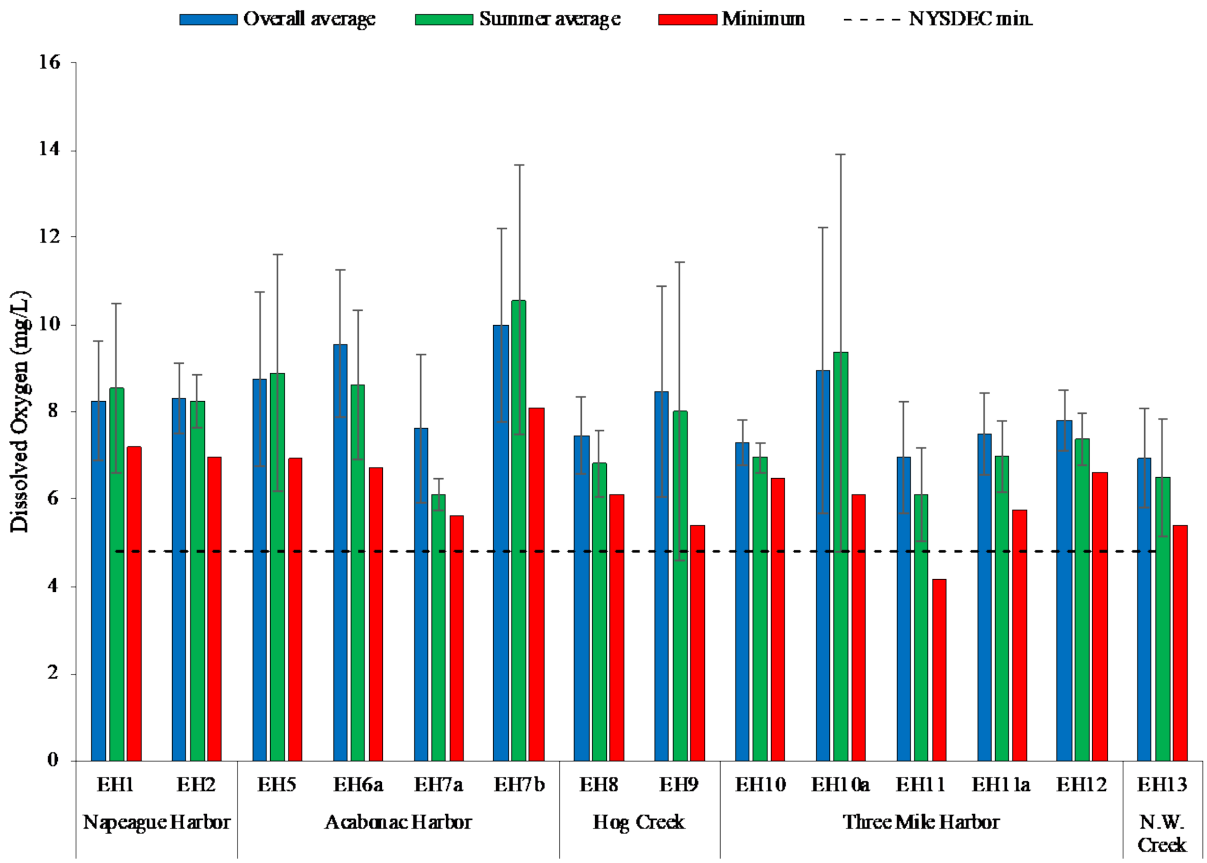


Figure 5. Overall average, summer average, and minimum surface water dissolved oxygen concentrations (mg/L) at various marine sites in East Hampton during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). Error bars represent standard deviation. N.W. Creek = Northwest Creek.

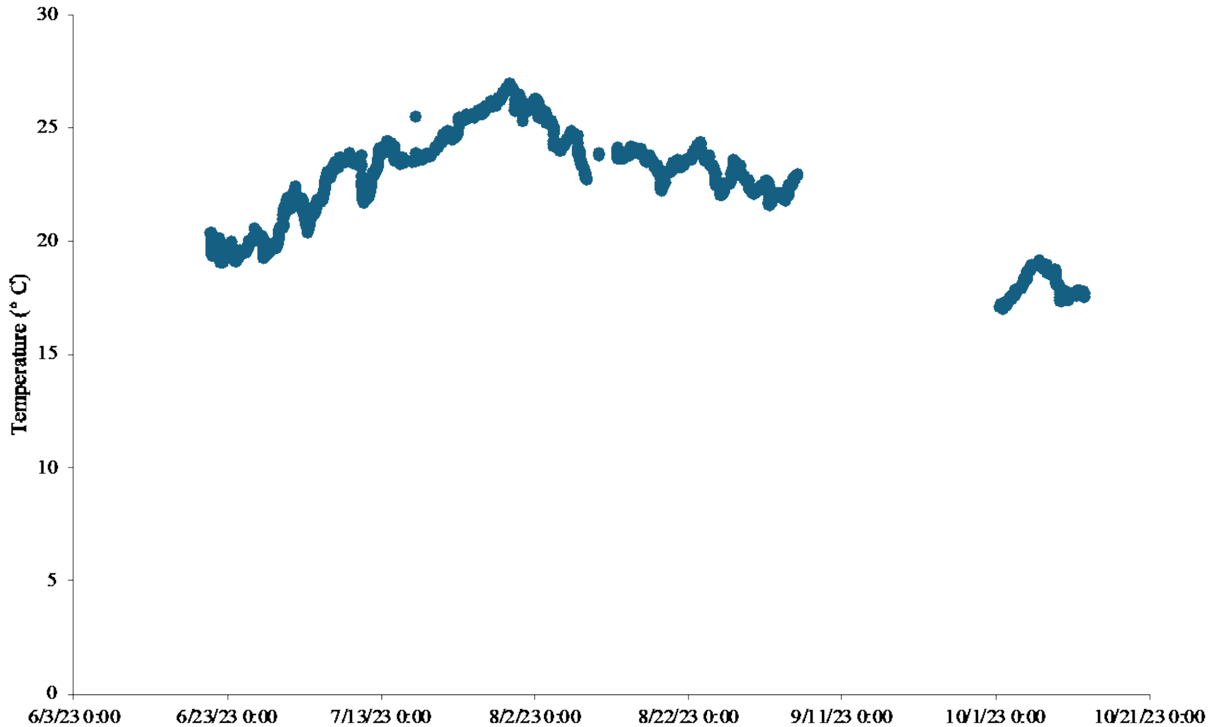


Figure 6. Continuous measurements of temperature (°C) in Three Mile Harbor (EH11) during summer 2023. Gaps in graph were when sensors were malfunctioning, and no data was recorded.

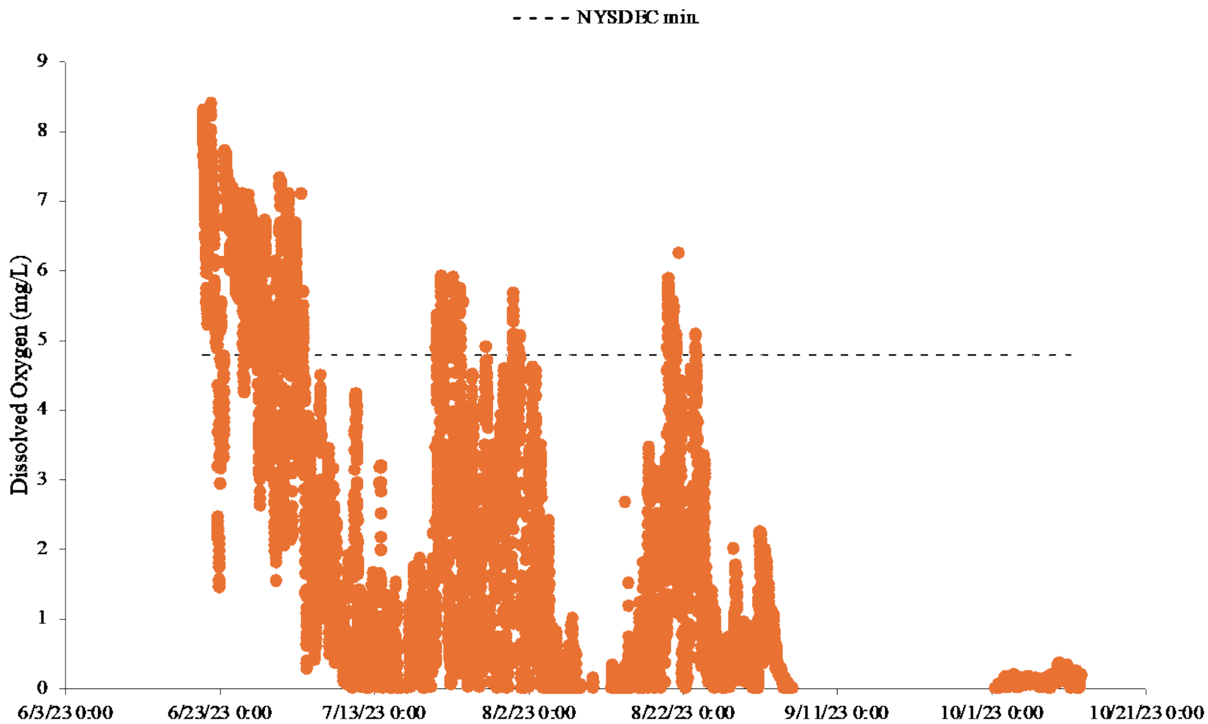


Figure 7. Discrete measurements of dissolved oxygen (mg/L) in Three Mile Harbor (EH11) during summer 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). Gaps in graph were when sensors were malfunctioning, and no data was recorded.

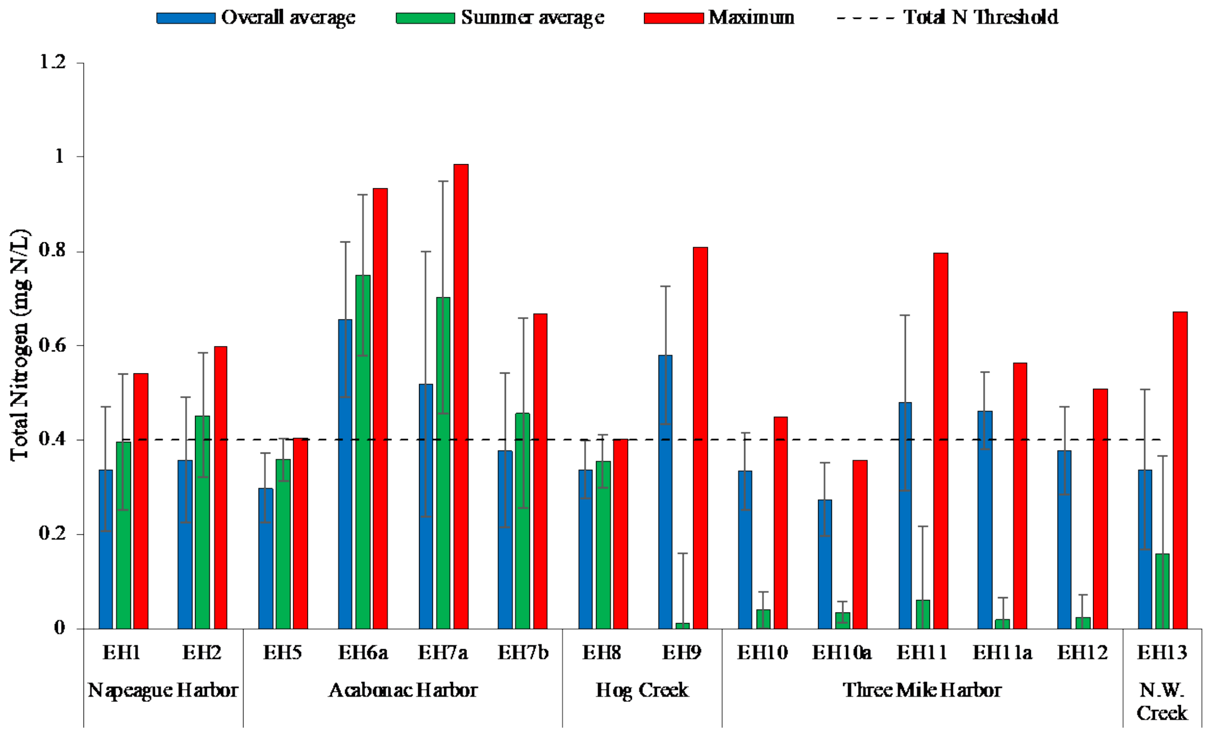


Figure 8. Overall average, summer average, and maximum dissolved total nitrogen concentrations at various marine sites in East Hampton during 2023. The dashed line represents the Peconic Estuary Program threshold for total nitrogen (0.4 mg N/L). Error bars represent standard deviation. N.W. Creek = Northwest Creek.

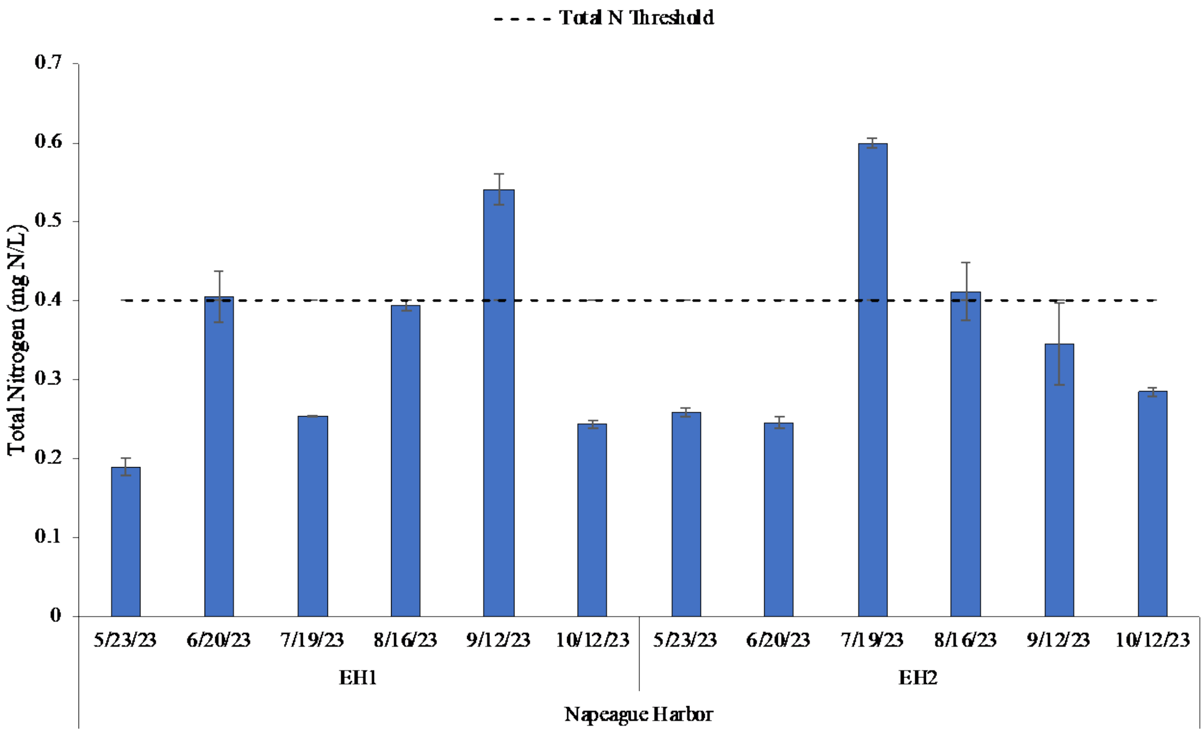


Figure 9. Total nitrogen (N) concentrations (mg N/L) at various marine sites in Napeague during 2023. Error bars represent standard deviation. The dashed horizontal lines represent the Peconic Estuary Program threshold for total N (0.4 mg N/L).

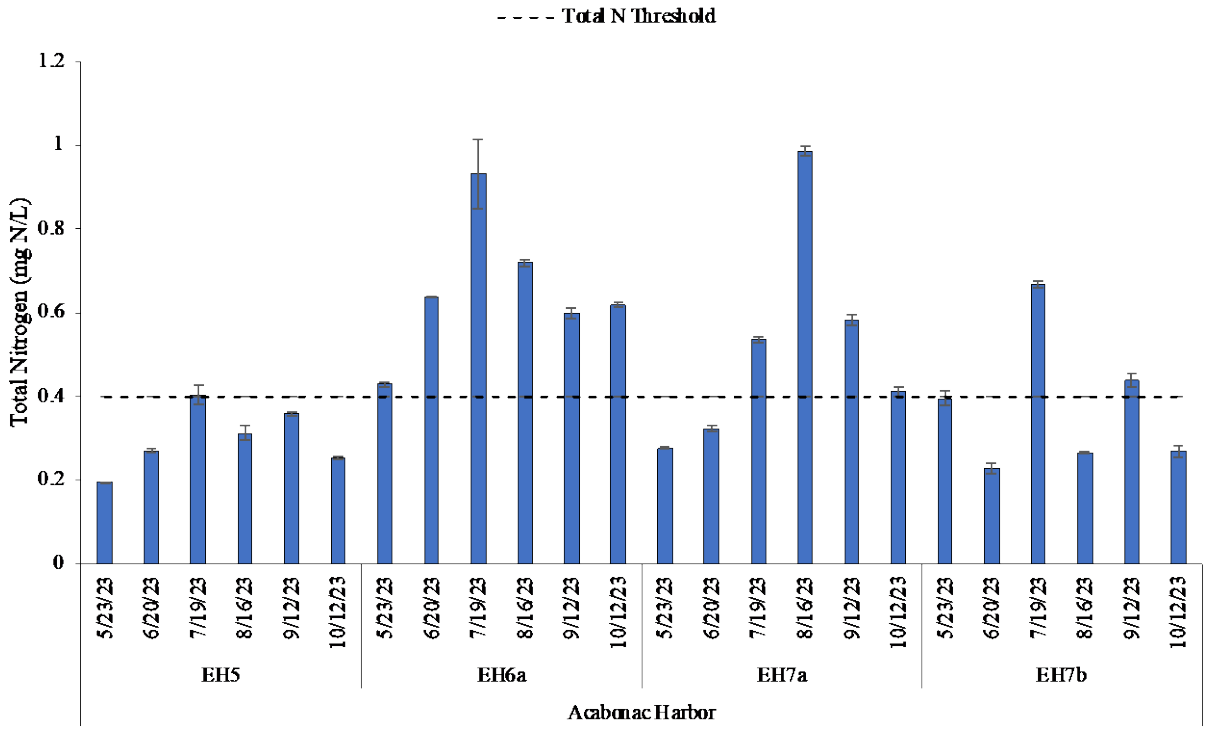


Figure 10. Total nitrogen (N) concentrations (mg N/L) at various marine sites in Hog Creek during 2023. Error bars represent standard deviation. The dashed horizontal lines represent the Peconic Estuary Program threshold for total N (0.4 mg N/L).

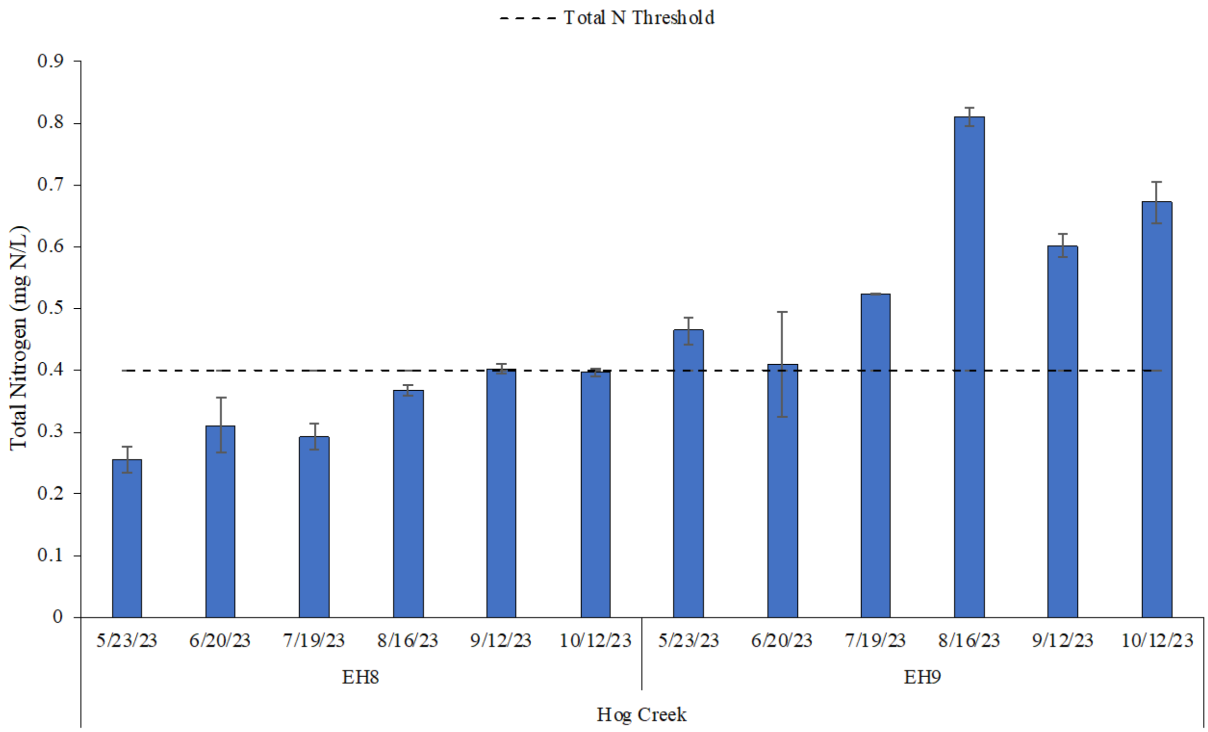


Figure 11. Total nitrogen (N) concentrations (mg N/L) at various marine sites in Hog Creek during 2023. Error bars represent standard deviation. The dashed horizontal lines represent the Peconic Estuary Program threshold for total N (0.4 mg N/L).

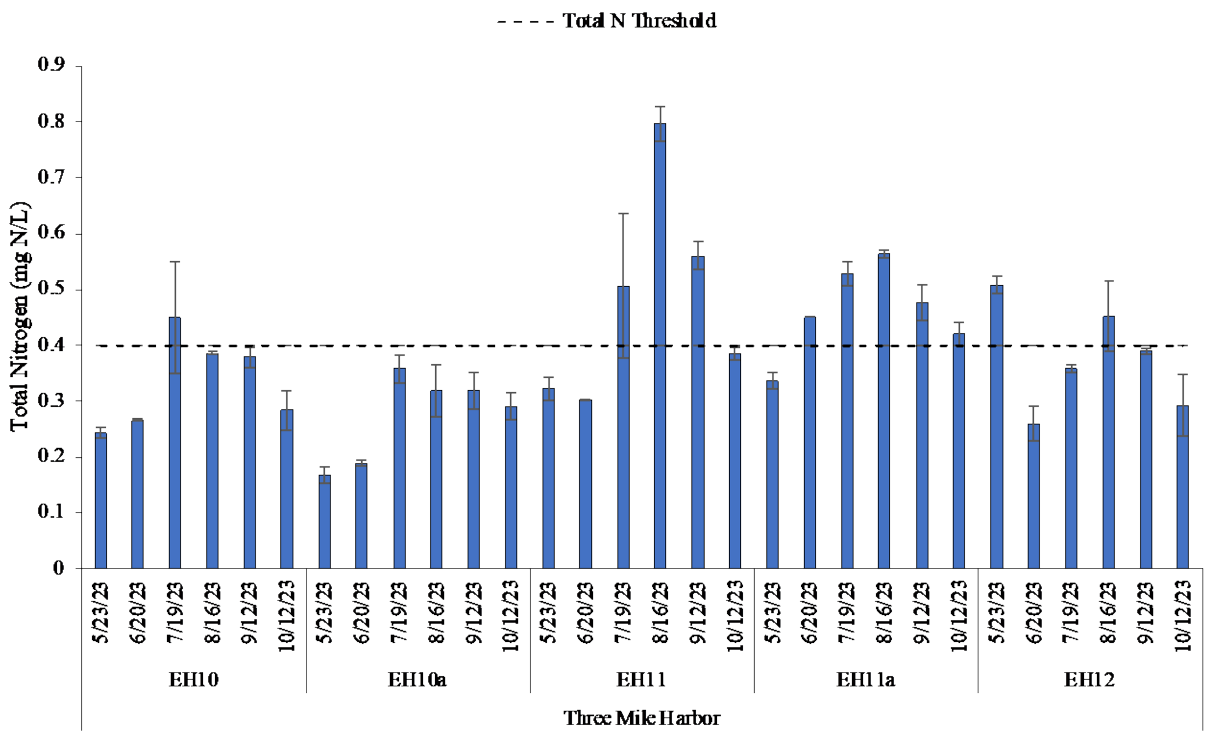


Figure 12. Total nitrogen (N) concentrations (mg N/L) at various marine sites in Three Mile Harbor during 2023. Error bars represent standard deviation. The dashed horizontal lines represent the Peconic Estuary Program threshold for total N (0.4 mg N/L).

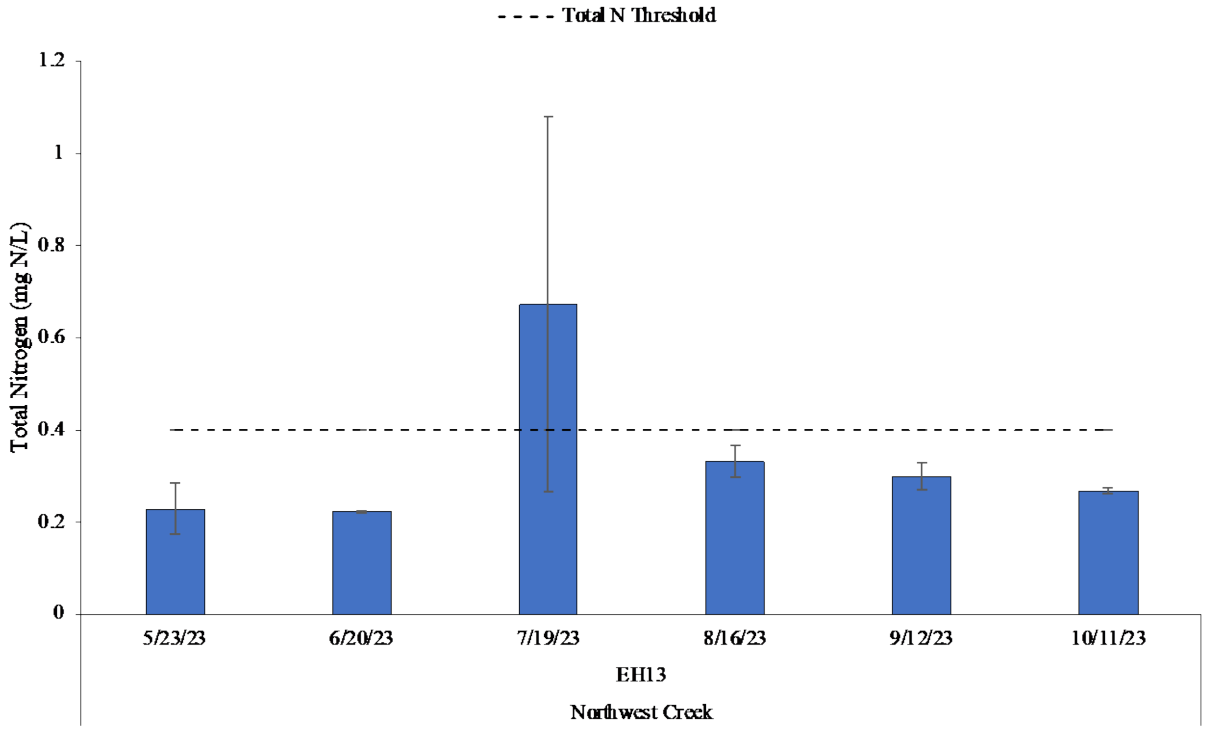


Figure 13. Total nitrogen (N) concentrations (mg N/L) at a marine site in Northwest Creek during 2023. Error bars represent standard deviation. The dashed horizontal lines represent the Peconic Estuary Program threshold for total N (0.4 mg N/L).

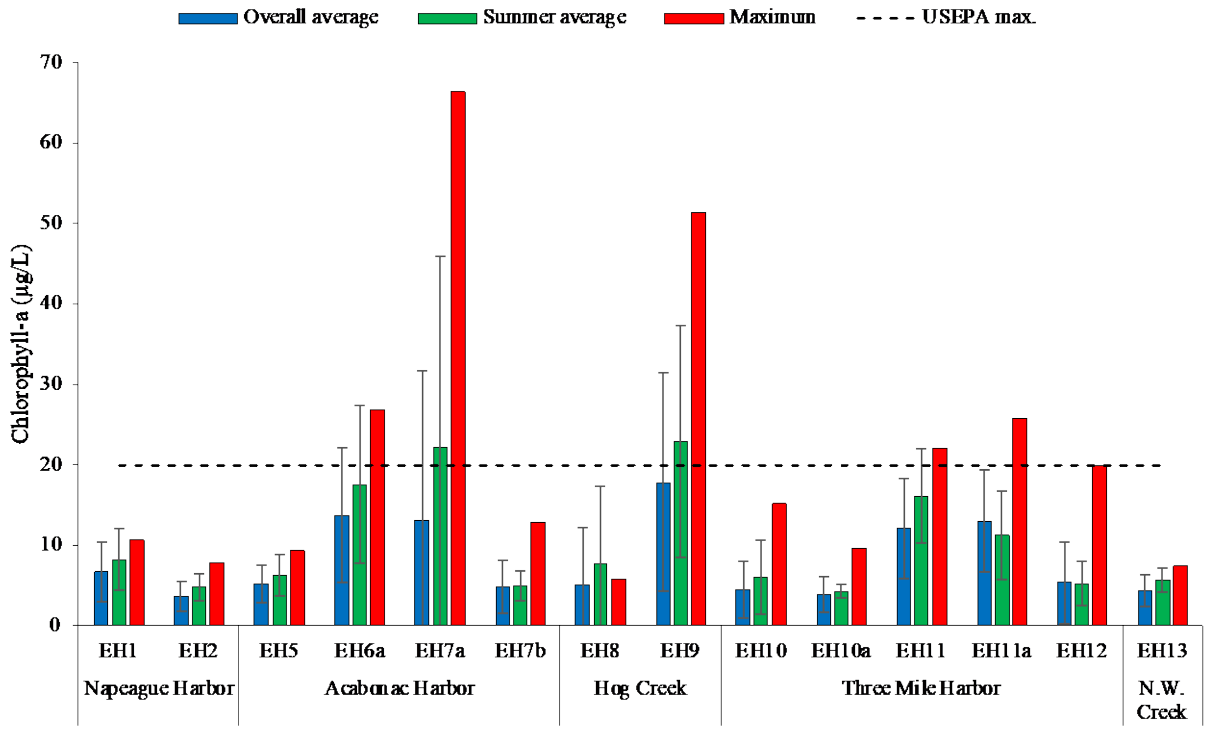


Figure 14. Overall average, summer average, and maximum chlorophyll-a concentration (µg/L) at various marine sites in East Hampton during 2023. The dashed line represents the NOAA maximum for chlorophyll-a (20 µg/L). Error bars represent standard deviation. N.W. Creek = Northwest Creek, respectively.

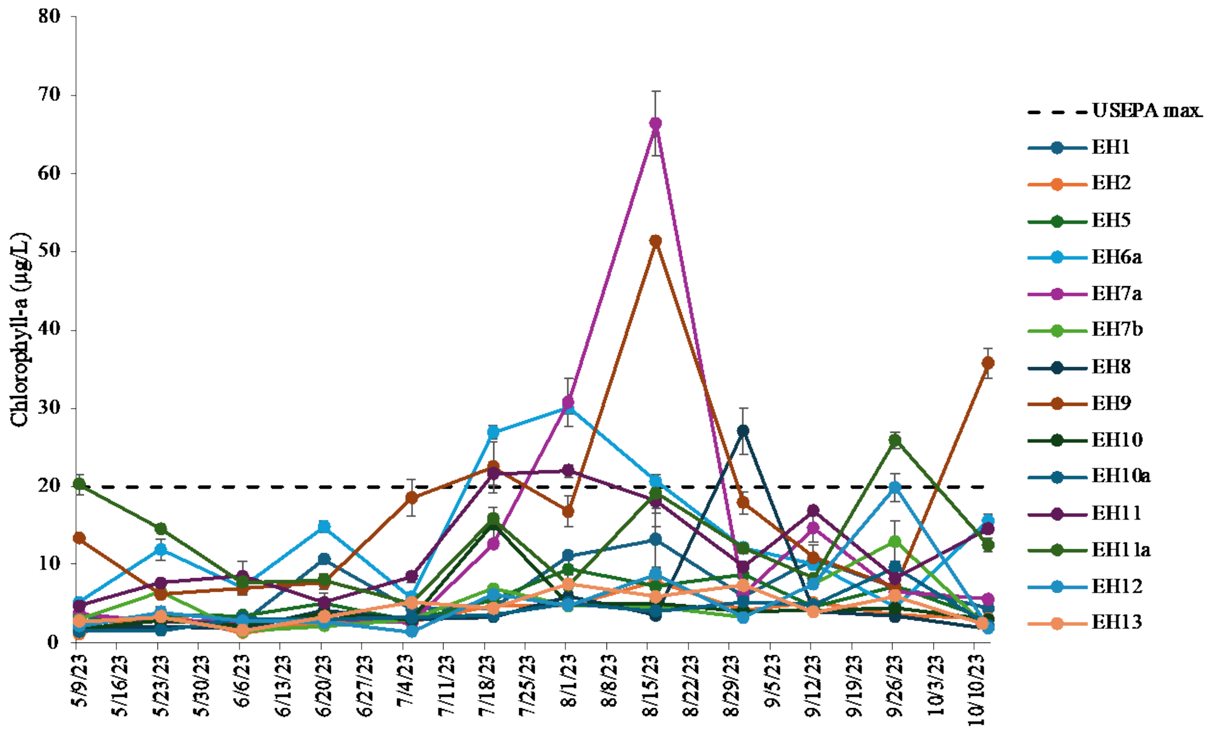


Figure 15. Chlorophyll-a concentrations (µg/L) at various marine sites in East Hampton during 2023. The dashed line represents the NOAA maximum for chlorophyll-a (20 µg/L). Error bars represent standard deviation.

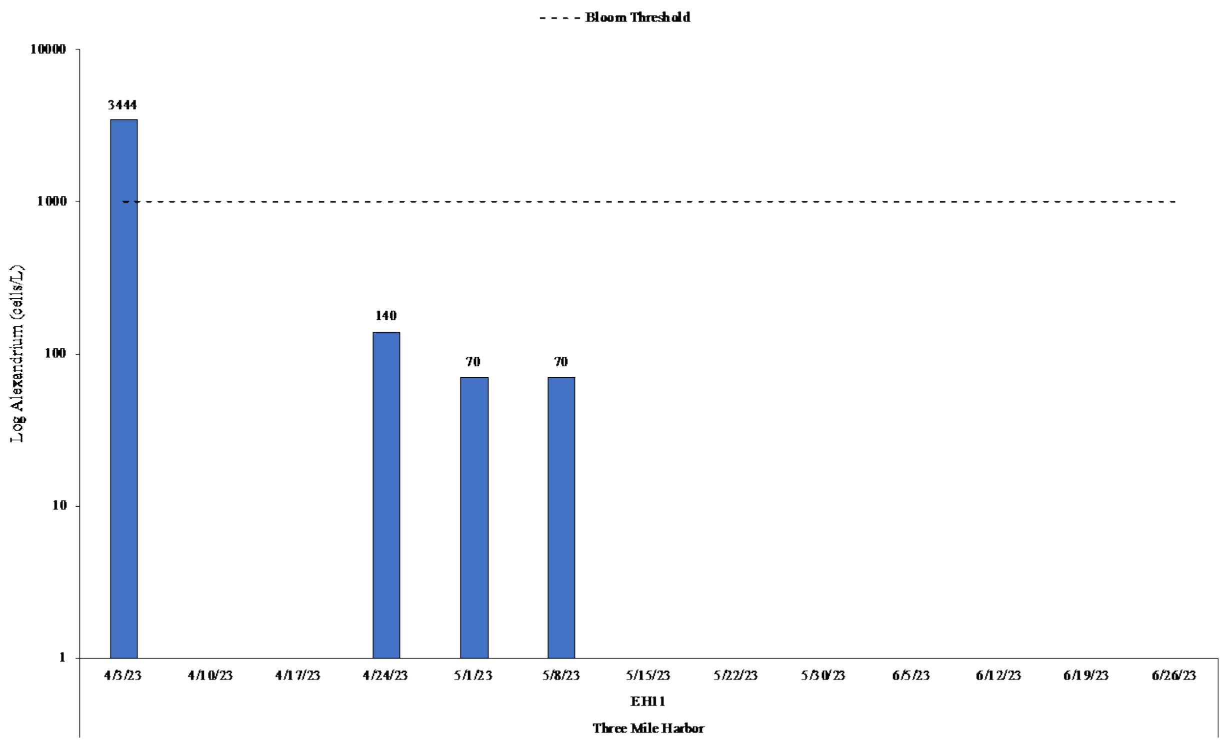


Figure 16. Concentrations of *Alexandrium* (cells/L) at one site in Three Mile Harbor during 2023. The dashed lines represent bloom thresholds for *Alexandrium* (1,000 cells/L).

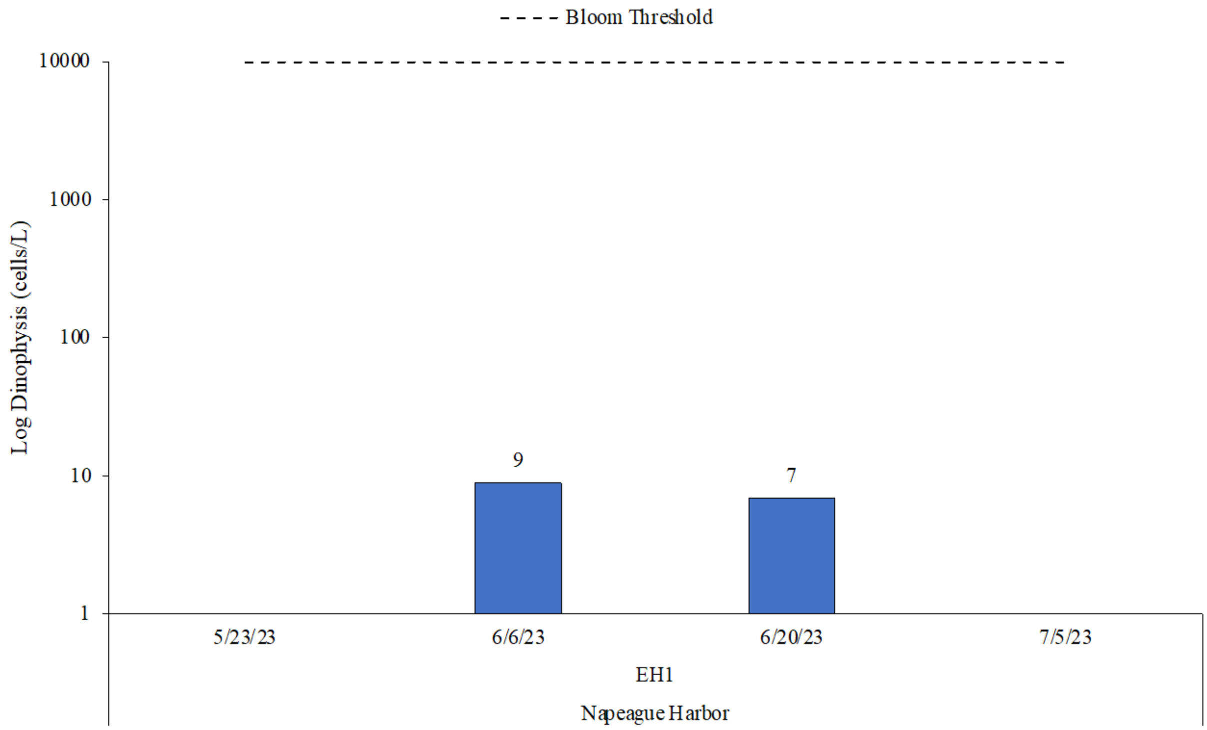


Figure 17. Concentrations of *Dinophysis* (cells/L) at one site in Napeague Harbor during 2023. The dashed lines represent bloom thresholds for *Dinophysis* (10,000 cells/L).

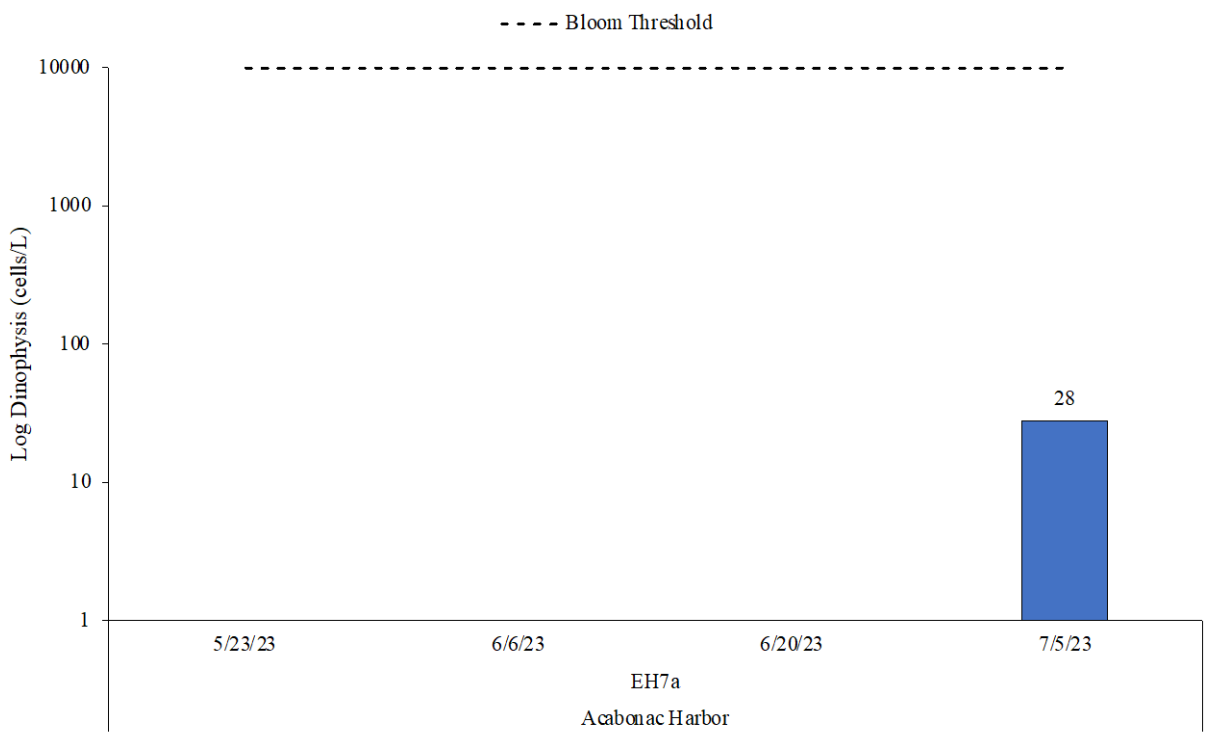


Figure 18. Concentrations of *Dinophysis* (cells/L) at one site in Acabonac Harbor during 2023. The dashed lines represent bloom thresholds for *Dinophysis* (10,000 cells/L).

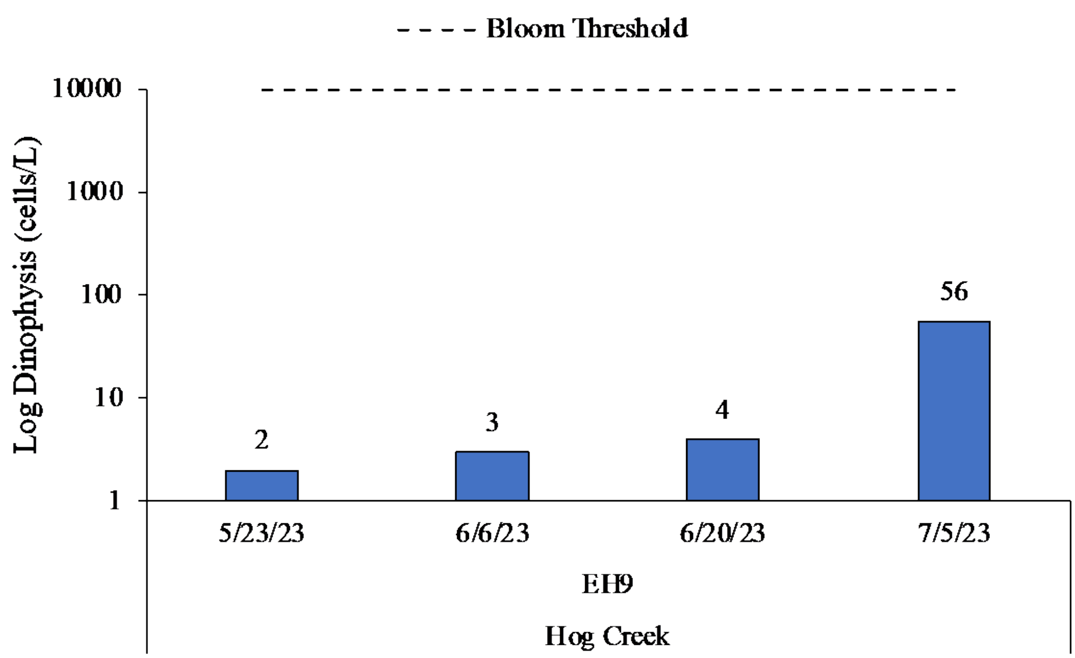


Figure 19. Concentrations of *Dinophysis* (cells/L) at one site in Hog Creek during 2023. The dashed lines represent bloom thresholds for *Dinophysis* (10,000 cells/L).

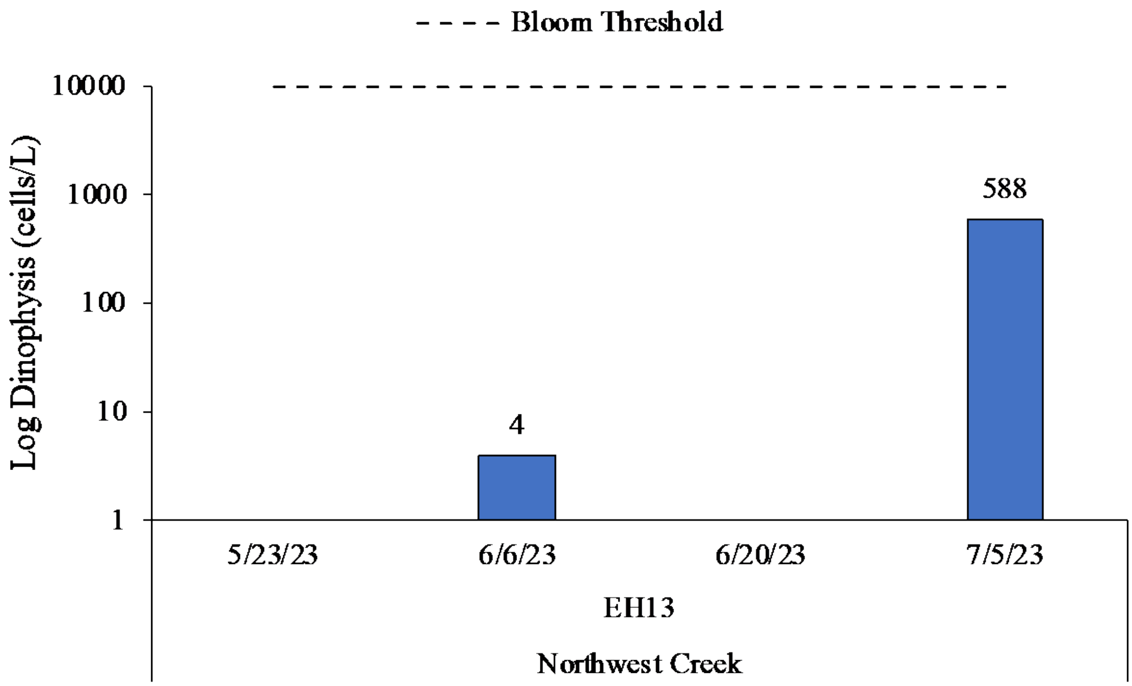


Figure 20. Concentrations of *Dinophysis* (cells/L) in Northwest Creek during 2023. The dashed lines represent bloom thresholds for *Dinophysis* (10,000 cells/L).

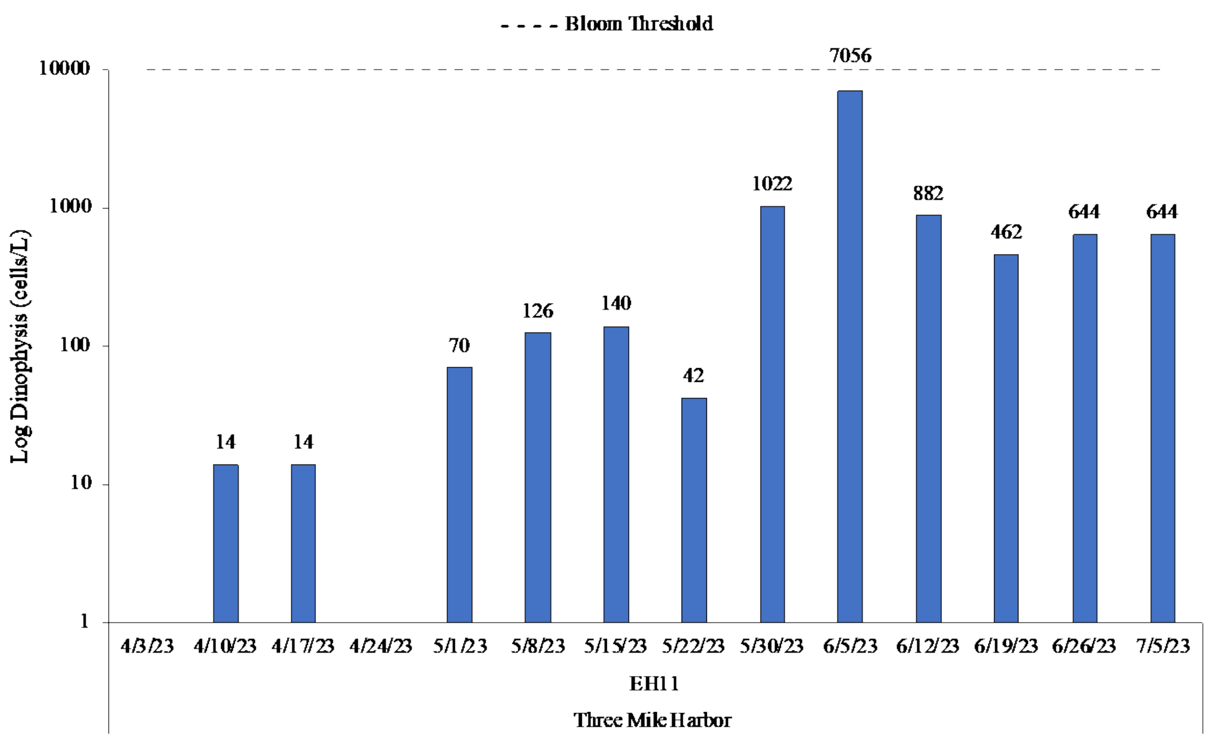


Figure 21. Concentrations of *Dinophysis* (cells/L) at one site in Three Mile Harbor during 2023. The dashed lines represent bloom thresholds for *Dinophysis* (10,000 cells/L).

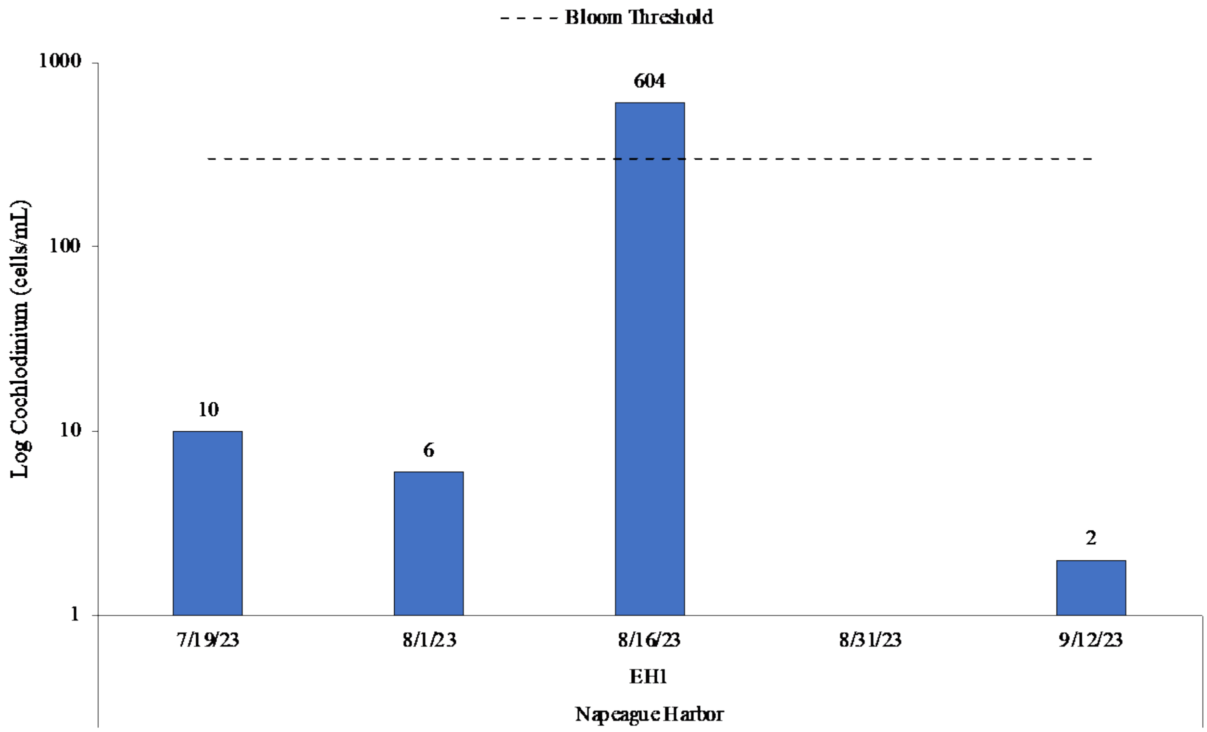


Figure 22. Concentrations of *Cochlodinium* (cells/mL) at one site in Napeague Harbor during 2023. The dashed lines represent bloom thresholds for *Cochlodinium* (300 cells/mL).

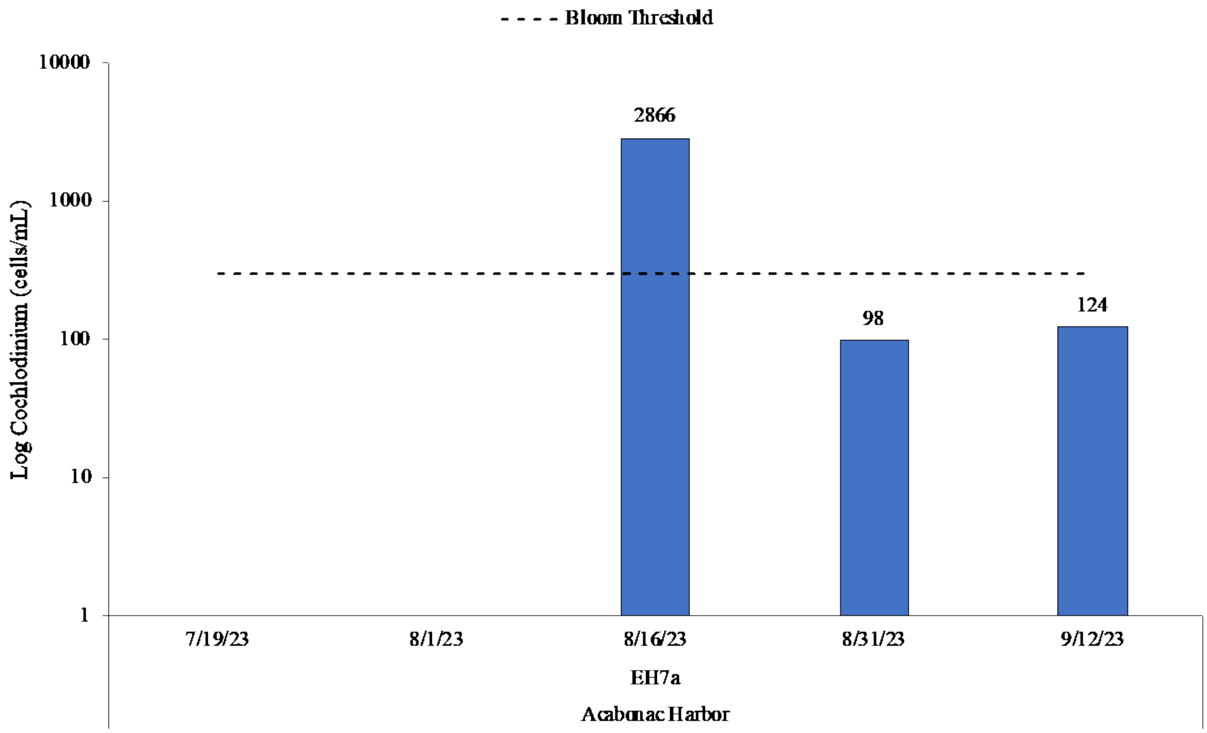


Figure 23. Concentrations of *Cochlodinium* (cells/mL) at one site in Acabonac Harbor during 2023. The dashed lines represent bloom thresholds for *Cochlodinium* (300 cells/mL).

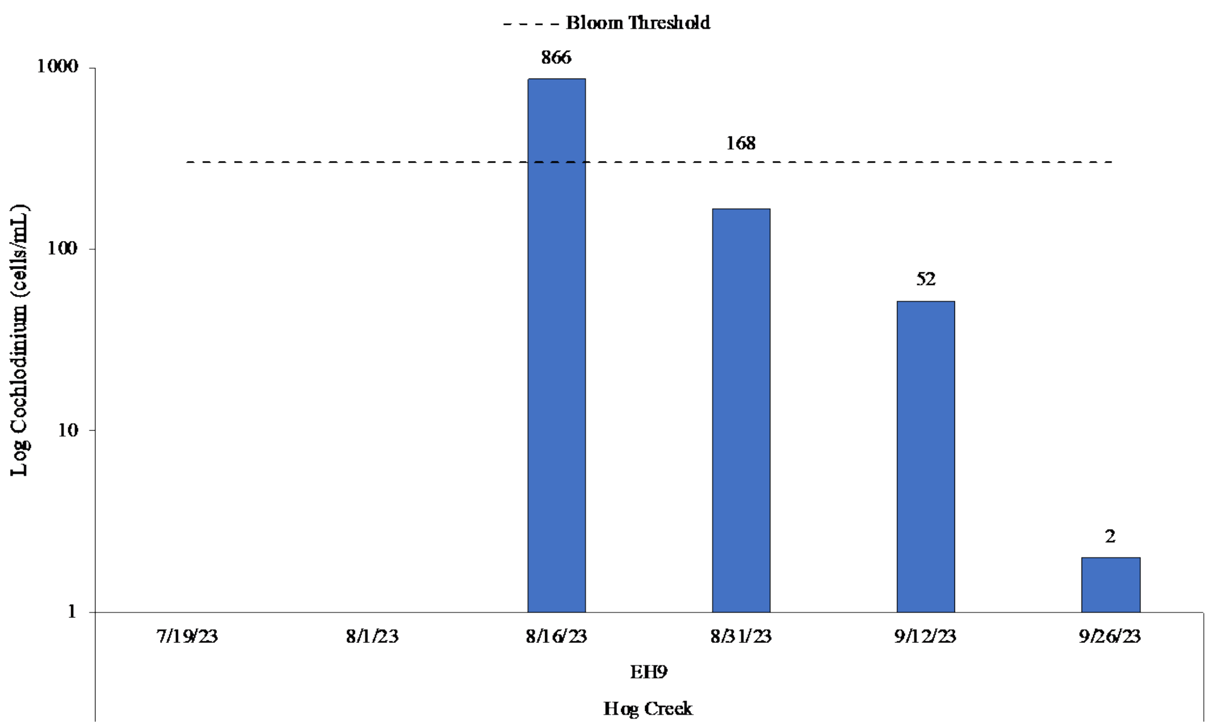


Figure 24. Concentrations of *Cochlodinium* (cells/mL) at one site in Hog Creek during 2023. The dashed lines represent bloom thresholds for *Cochlodinium* (300 cells/mL).

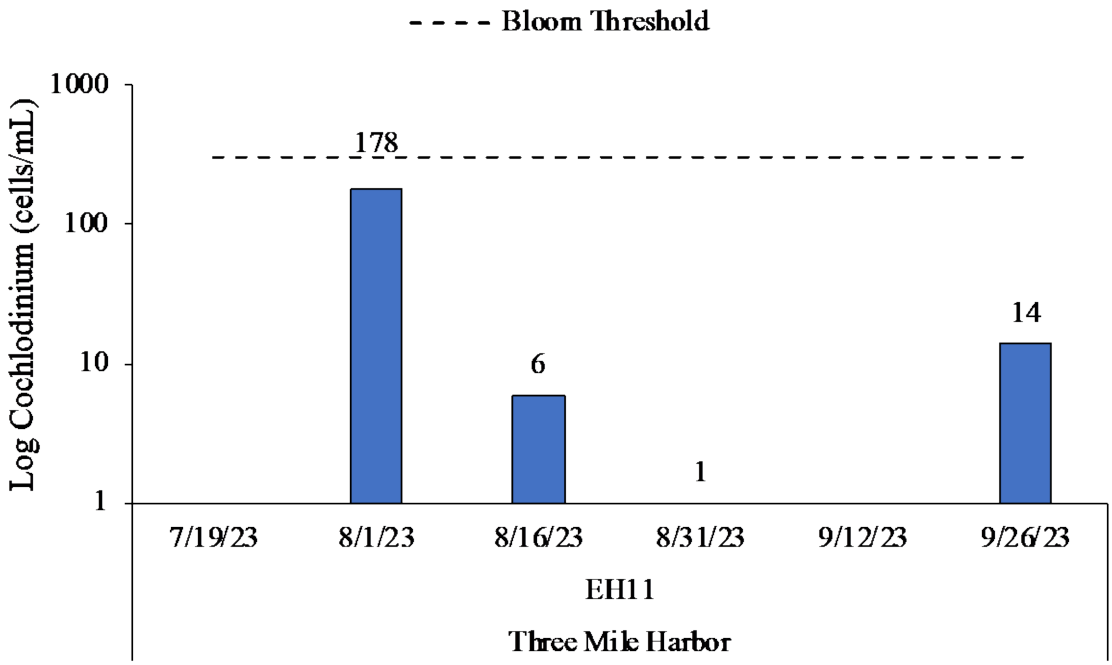


Figure 25. Concentrations of *Cochlodinium* (cells/mL) at one site in Three Mile Harbor during 2023. The dashed lines represent bloom thresholds for *Cochlodinium* (300 cells/mL).

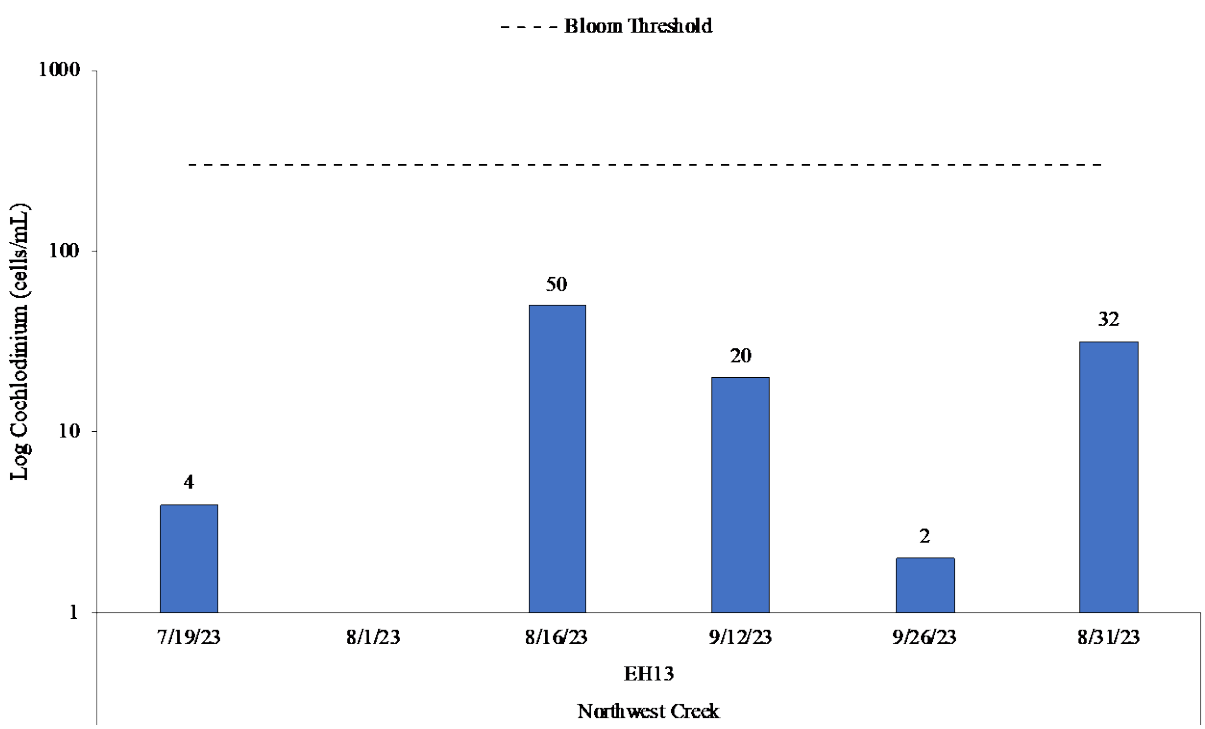
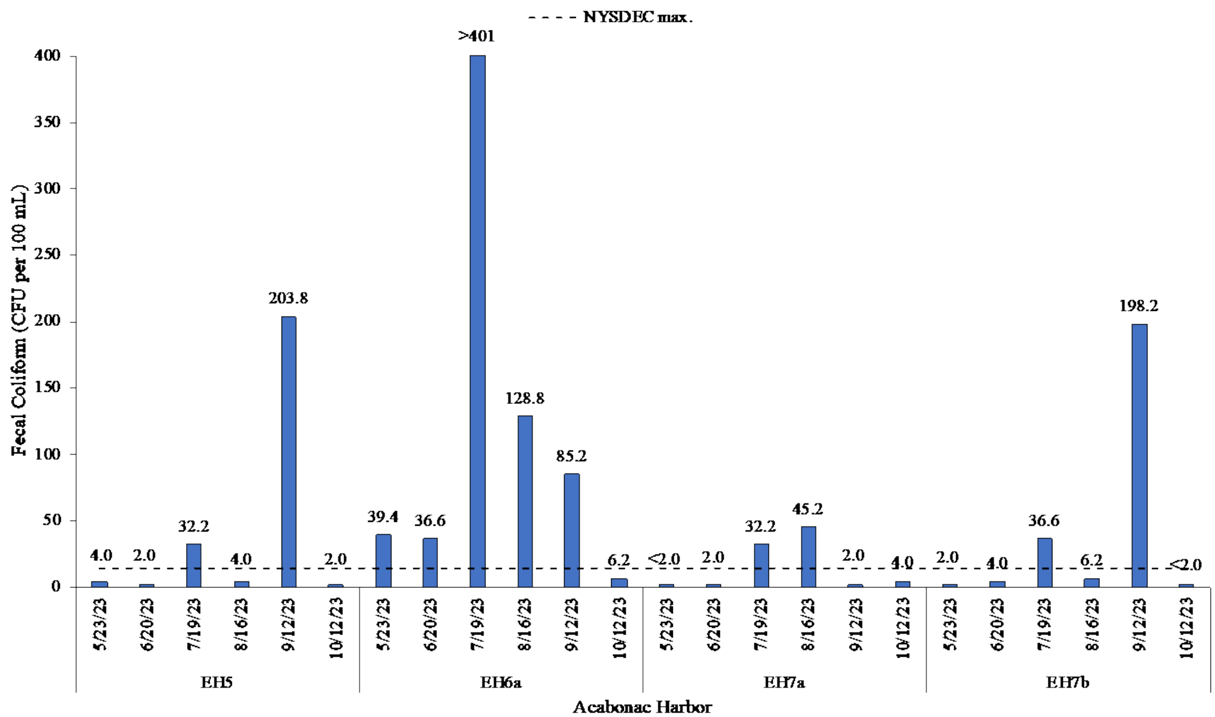


Figure 26. Concentrations of *Cochlodinium* (cells/mL) at Northwest Creek during 2023. The dashed lines represent bloom thresholds for *Cochlodinium* (300 cells/mL).



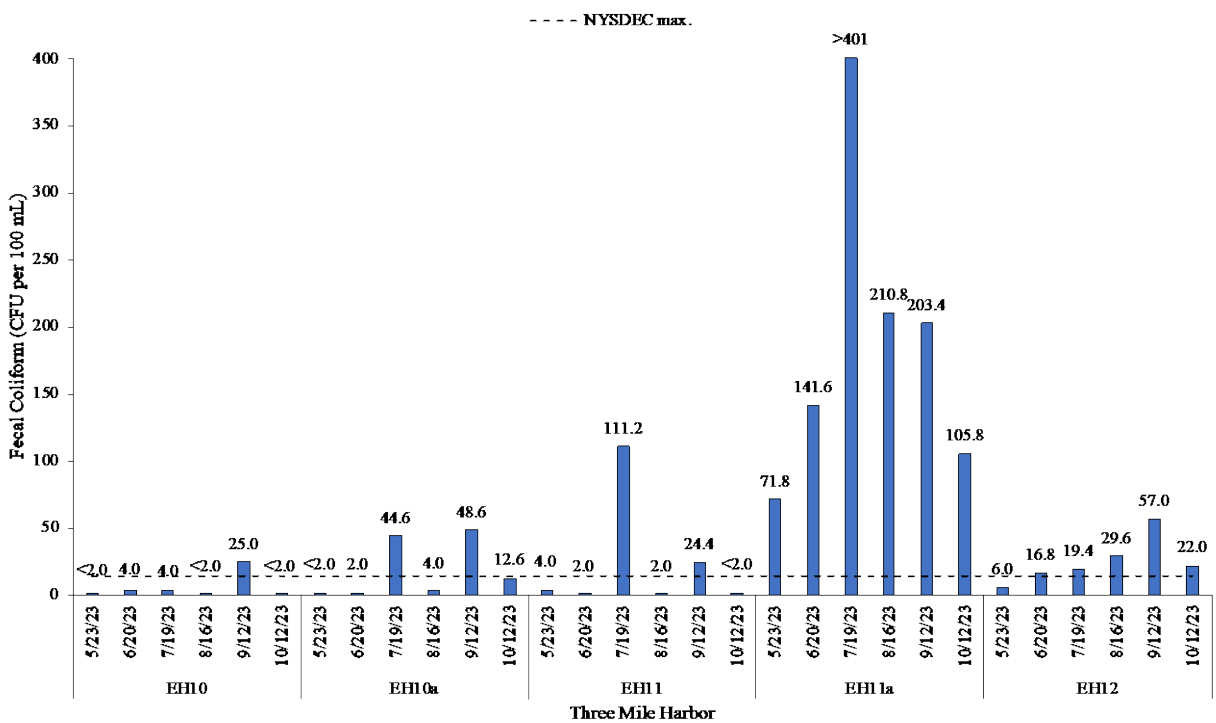
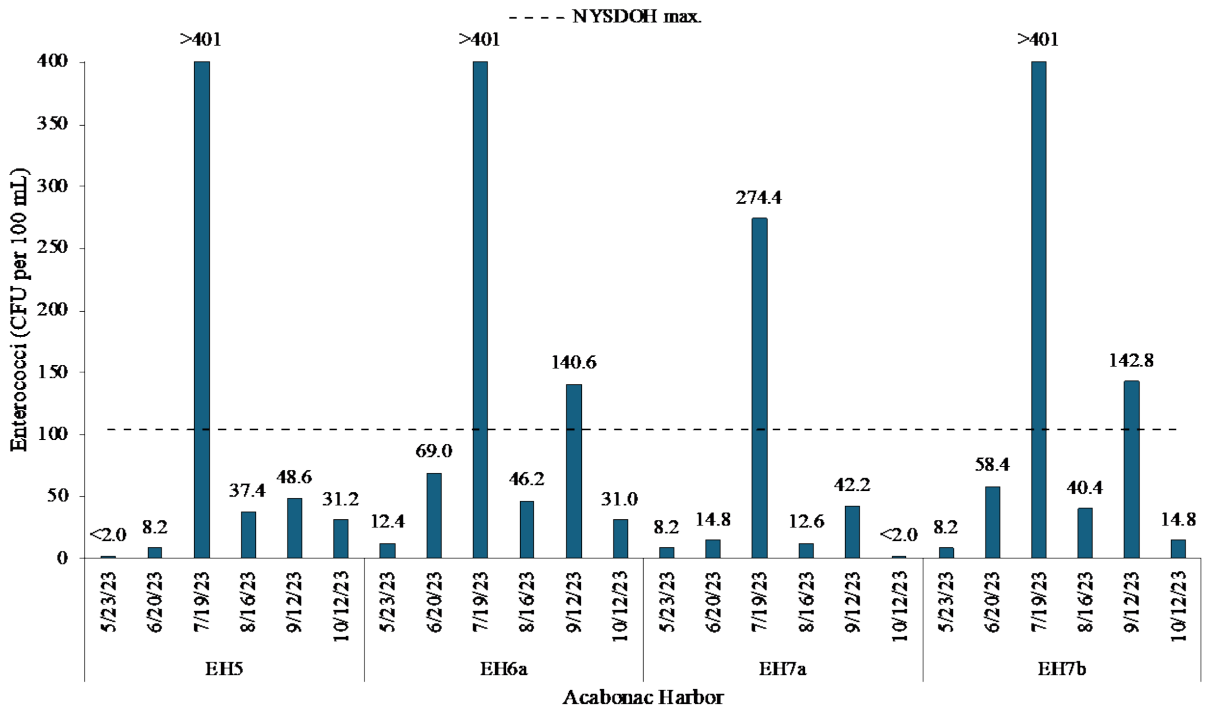


Figure 27. Fecal coliform levels (CFU per 100 mL) at various sites in Acabonac Harbor and Three Mile Harbor during 2023. The dashed lines are the NYSDEC maximum fecal coliform levels for shellfishing (14 CFU per 100 mL).



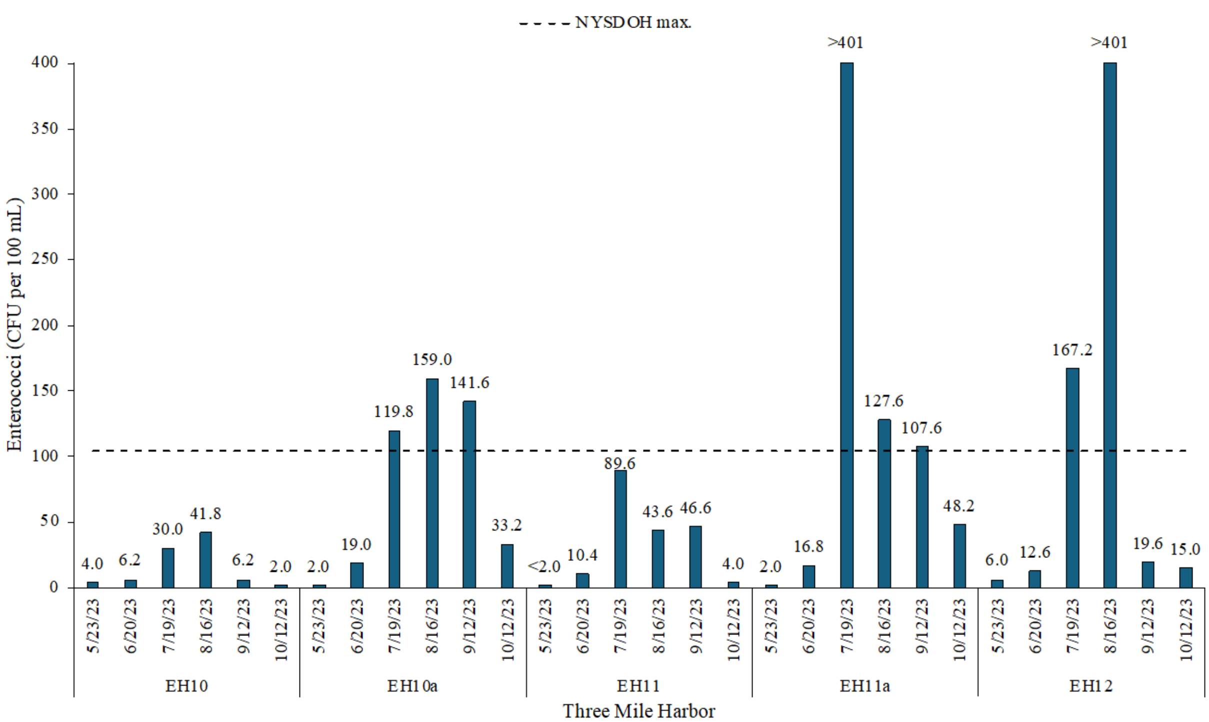


Figure 28. Enterococci levels (CFU per 100 mL) at various sites in Acabonac Harbor and Three Mile Harbor during 2023. The dashed lines are the NYSDOH maximum enterococci levels for recreational use (104 CFU per 100 mL).

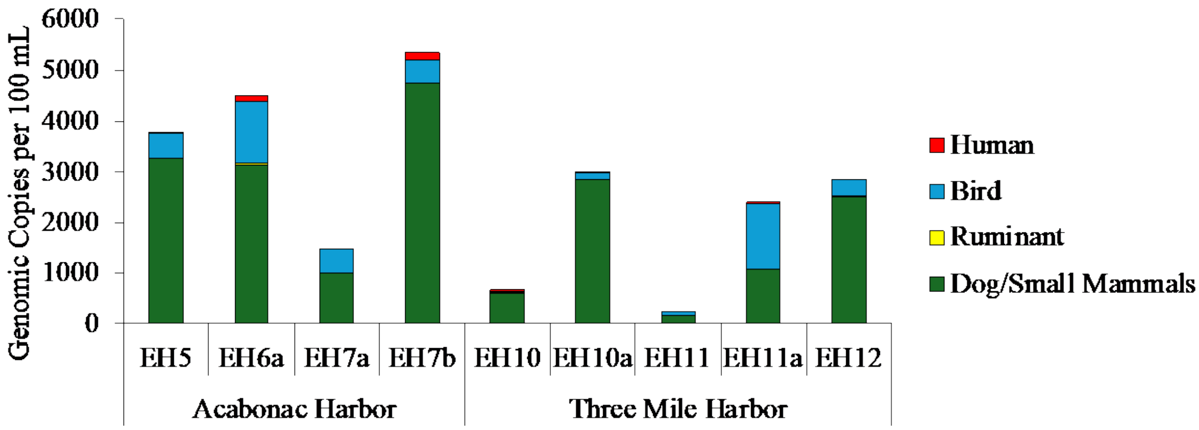


Figure 29. Summer averages of four classes of fecal bacteria (human, bird, ruminant, and dog/small mammal) in Acabonac Harbor and Three Mile Harbor during 2023.

Figure 30. Summer average of enterococcus bacteria in Acabonac Harbor and Three Mile Harbor during 2023.

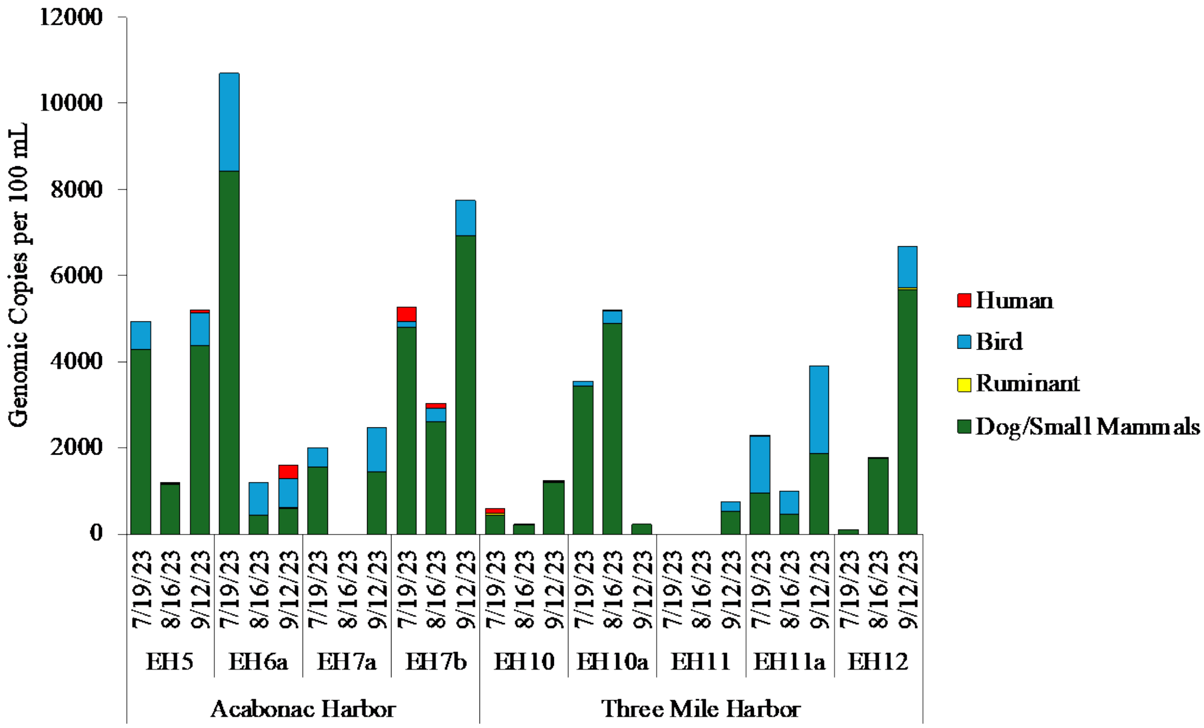


Figure 31. Time-series of four classes of fecal bacteria (human, bird, ruminant, and dog/small mammal) in Acabonac Harbor and Three Mile Harbor during 2023.

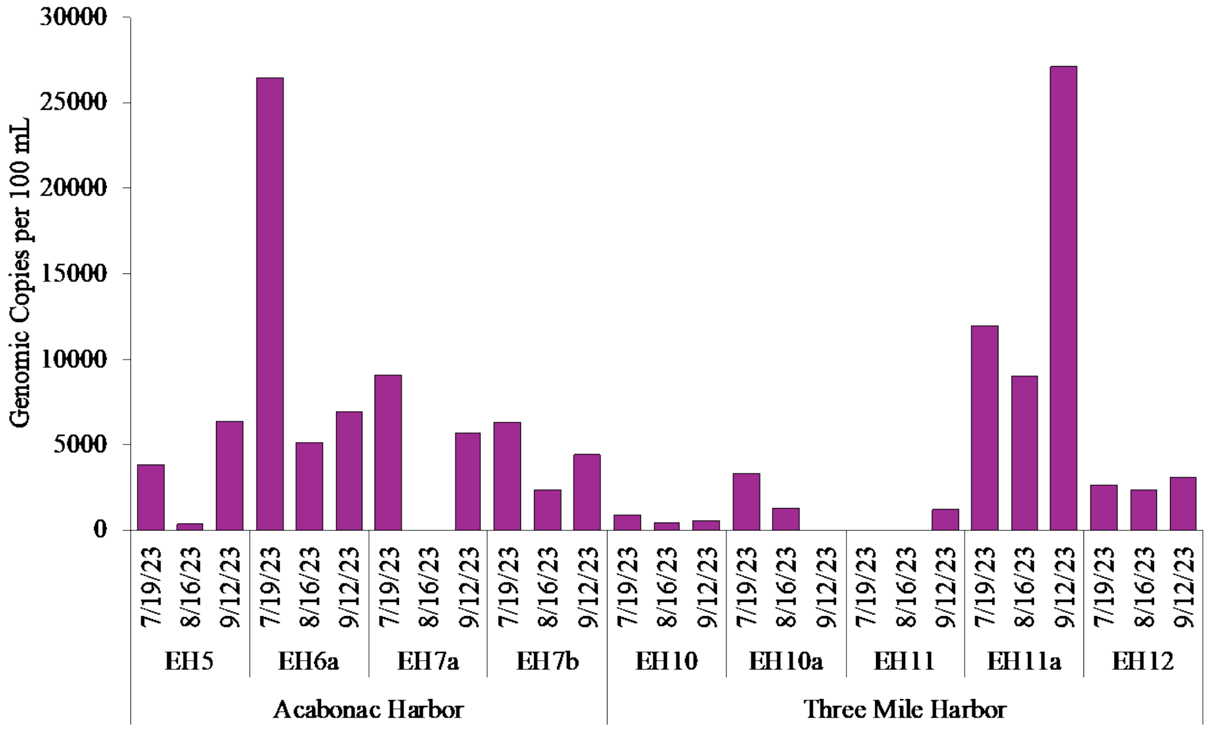


Figure 32. Time-series of enterococcus bacteria in Acabonac Harbor and Three Mile Harbor during 2023.

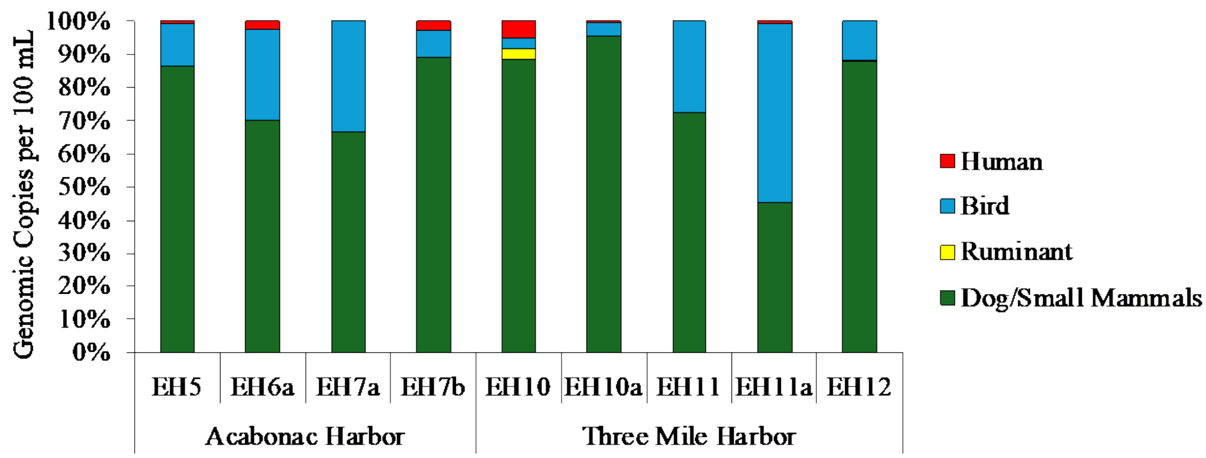


Figure 33. Average relative abundance of four classes of fecal bacteria (human, bird, deer, dog/small mammal) in Acabonac Harbor and Three Mile Harbor during summer 2023.

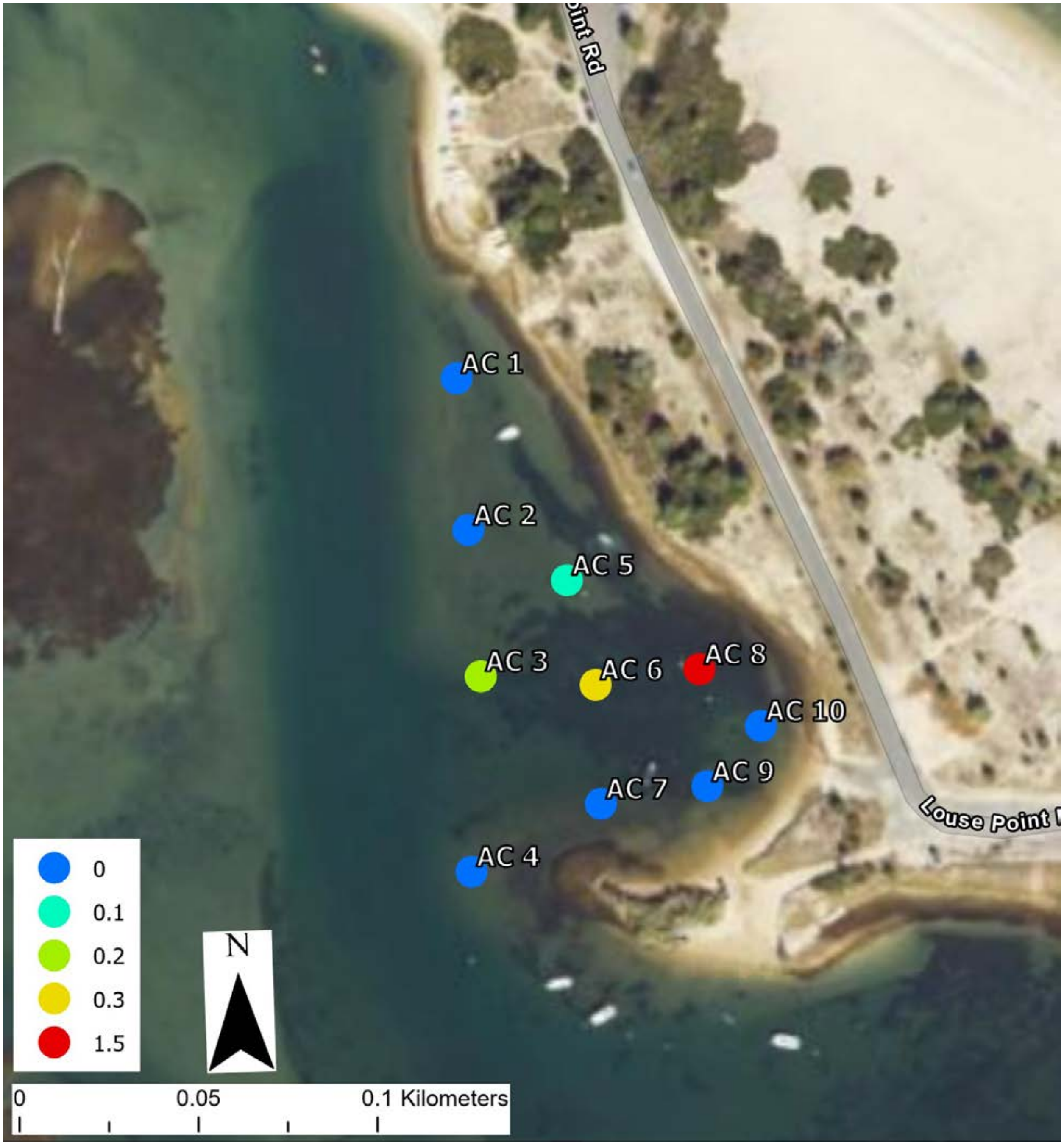


Figure 34. Sediment depth at each site in Acabonac Harbor in 2023.

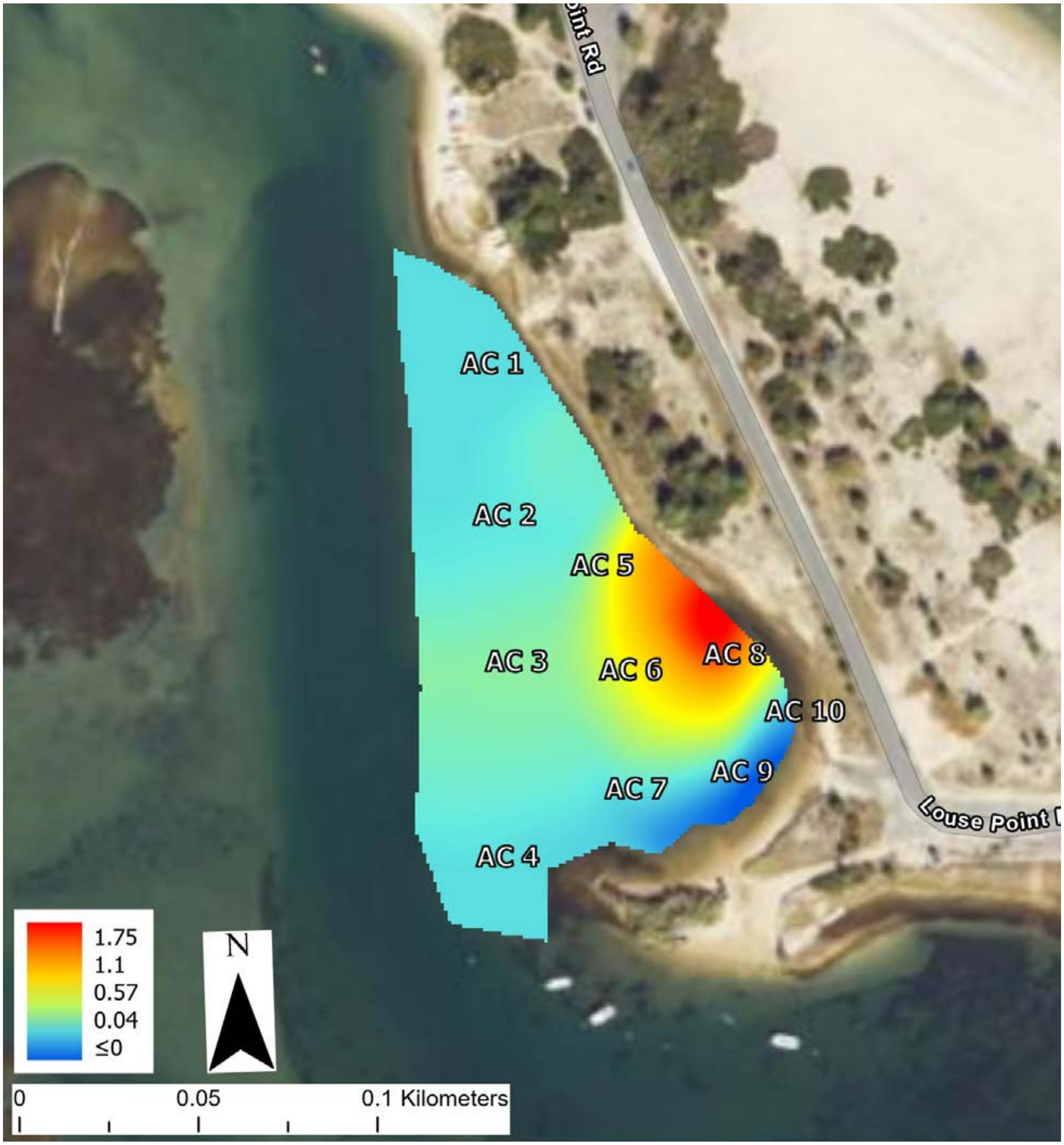


Figure 35. Interpolation of sediment depth in Acabonac Harbor in 2023

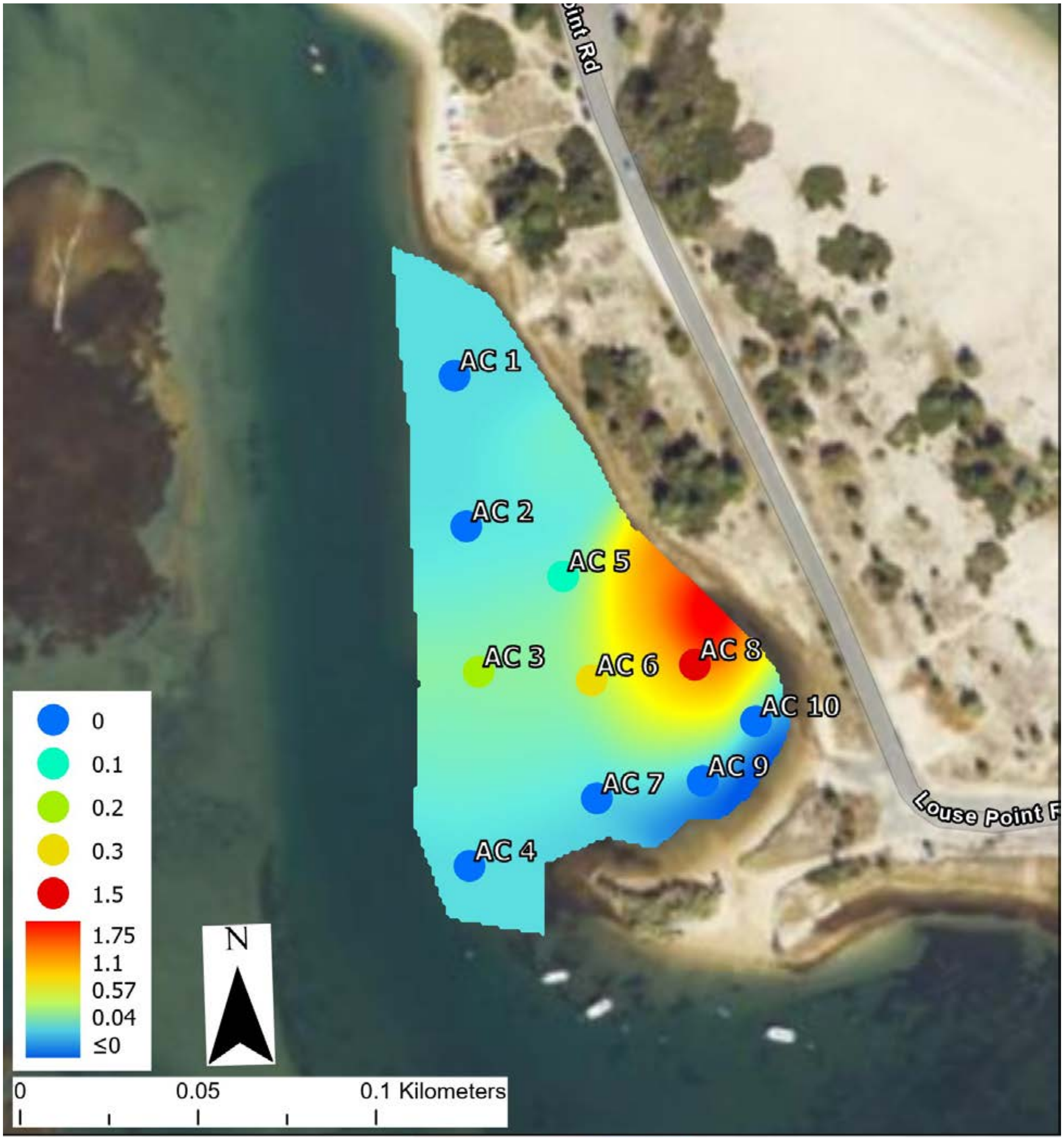


Figure 36. Sediment depth at each site with interpolation at Acabonac Harbor in 2023.

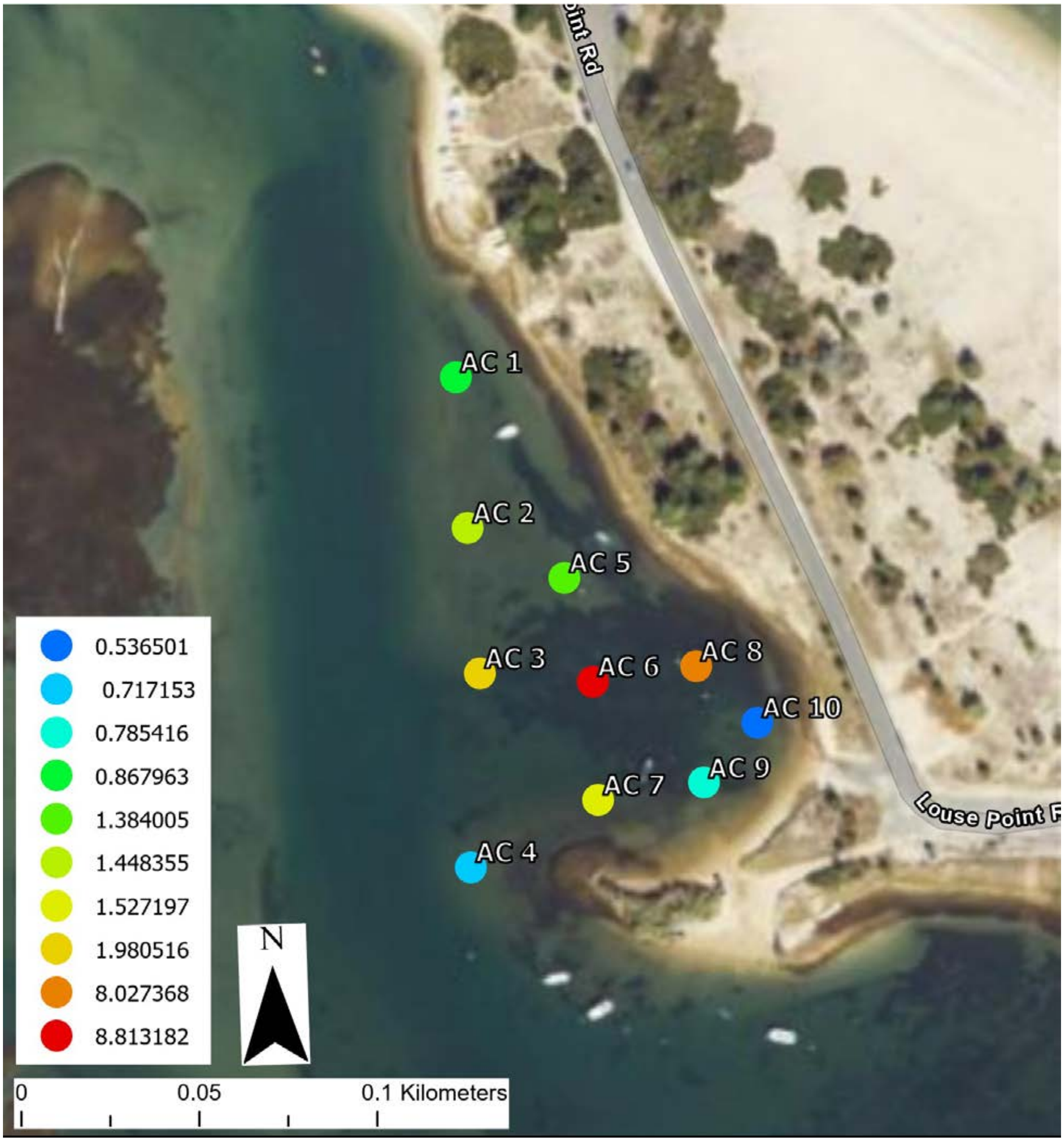


Figure 37. Percent organic matter at each site in Acabonac Harbor in 2023.

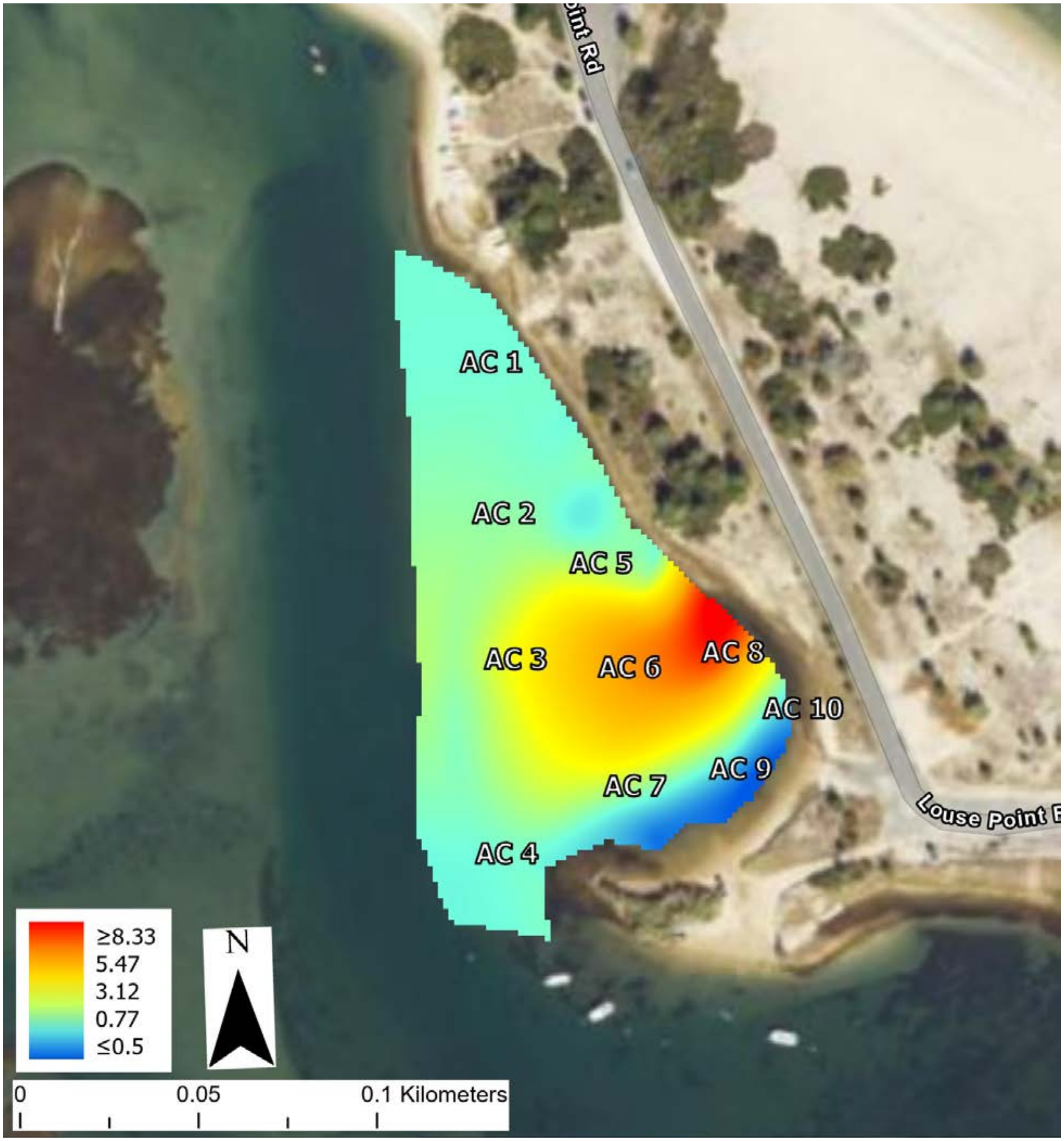


Figure 38. Interpolation of percent organic matter in Acabonac Harbor in 2023.

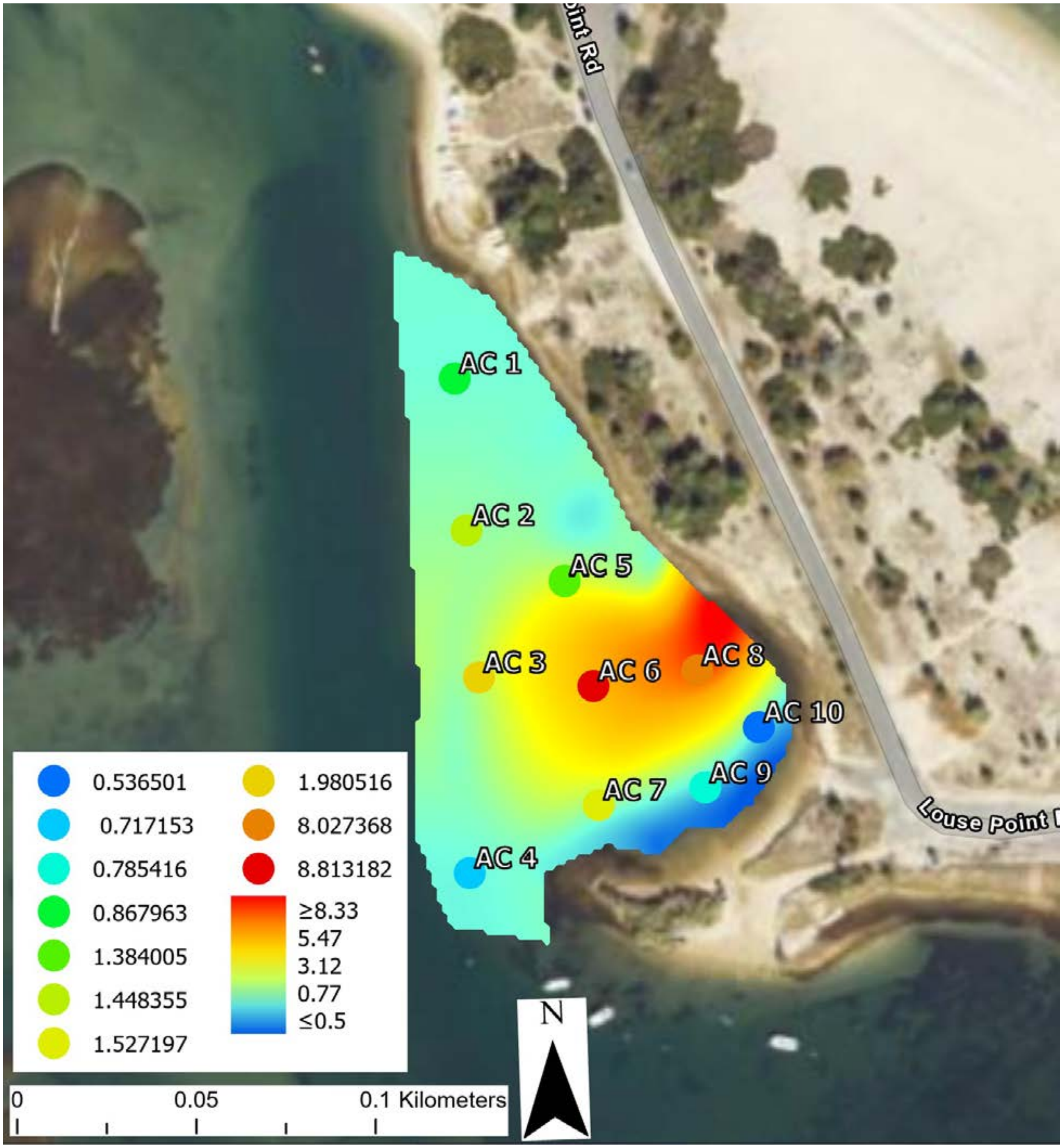


Figure 39. Percent organic matter at each site with interpolation in Acabonac Harbor 2023

Figure 40. Sediment quality at each site in Acabonac Harbor in 2023.

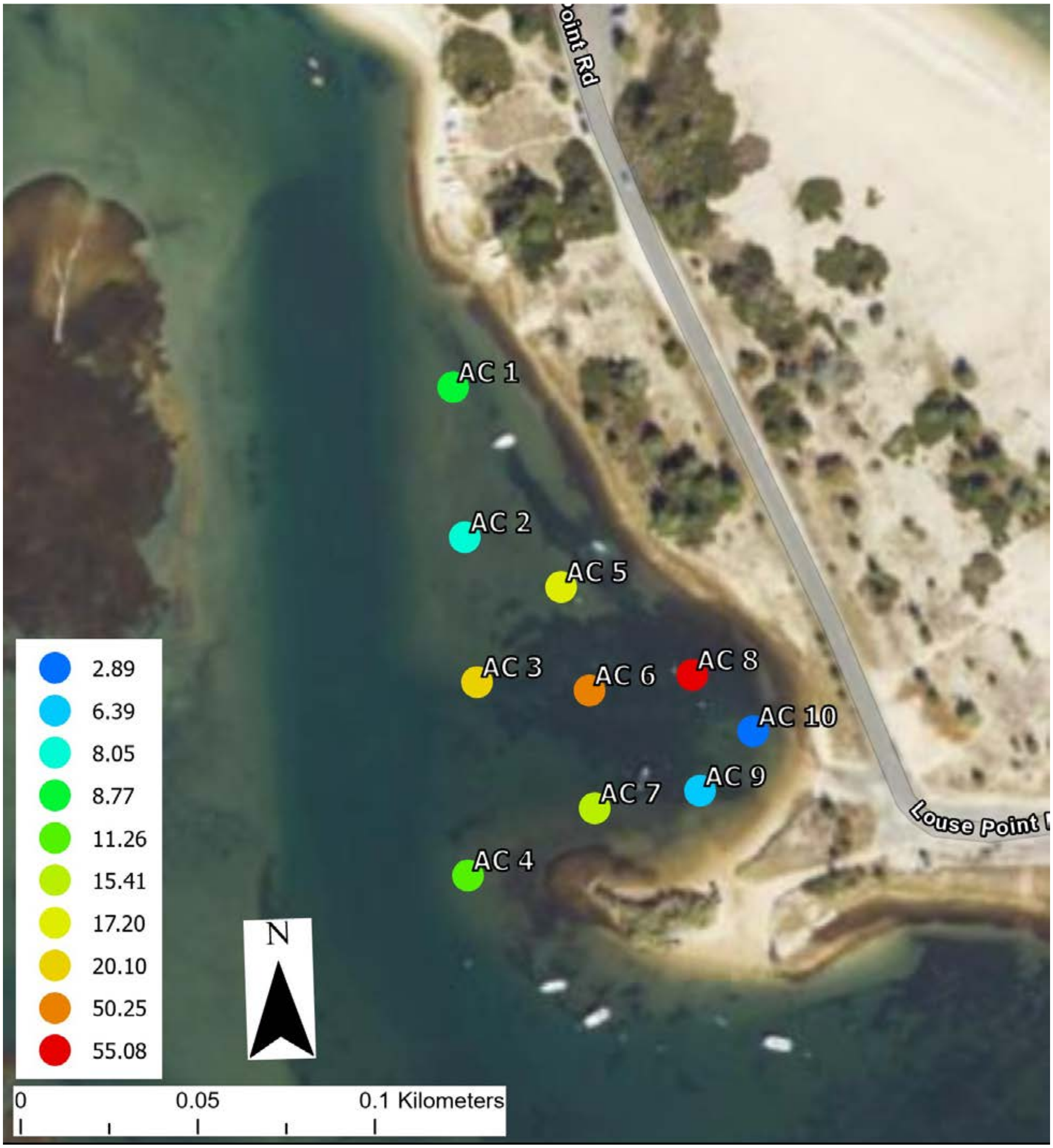


Figure 41. Percent by weight of sediment <90 µm at each site in Acabonac Harbor in 2023.

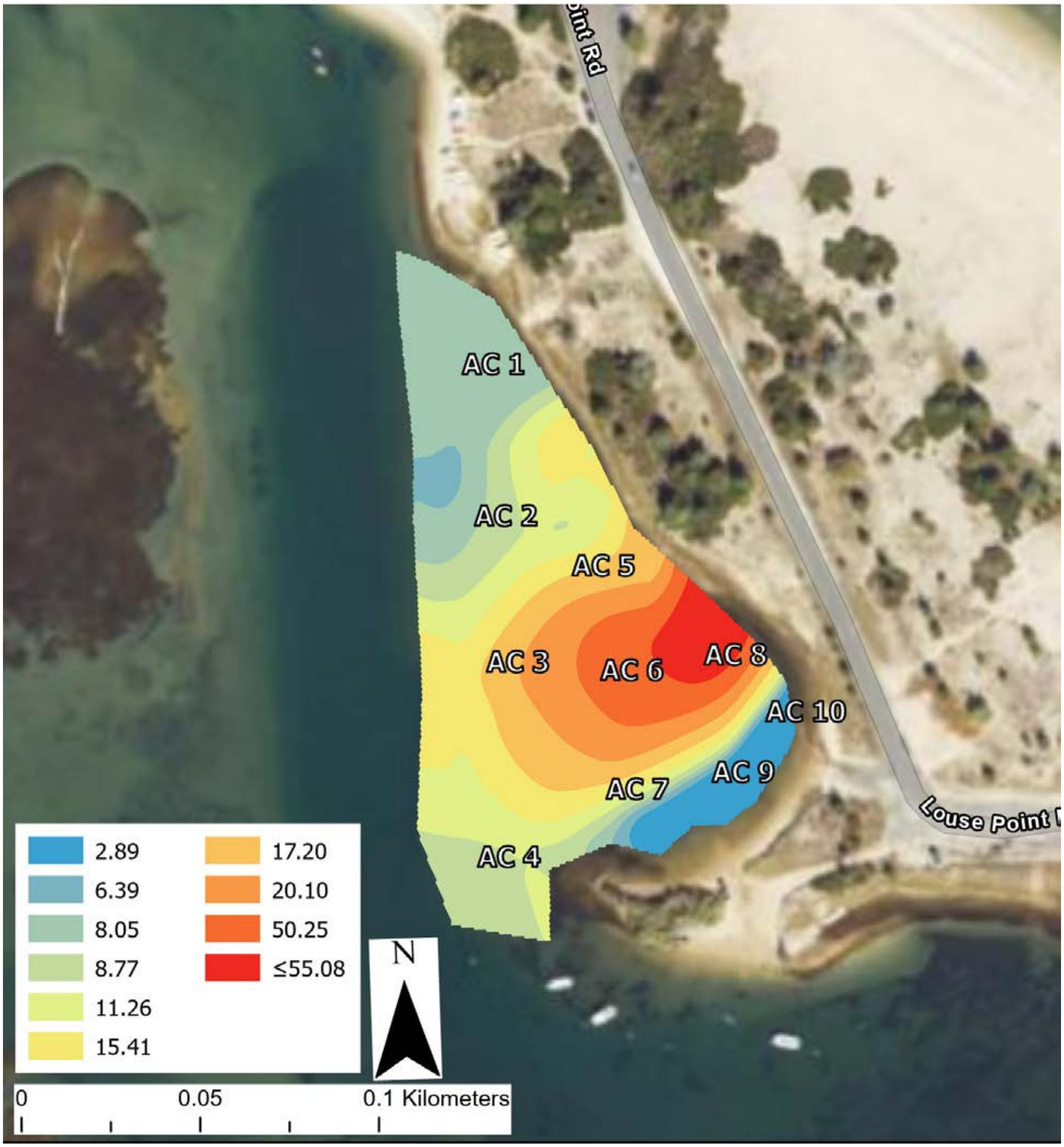


Figure 42. Interpolation of percent by weight of sediment <90 µm at each site in Acabonac Harbor in 2023.

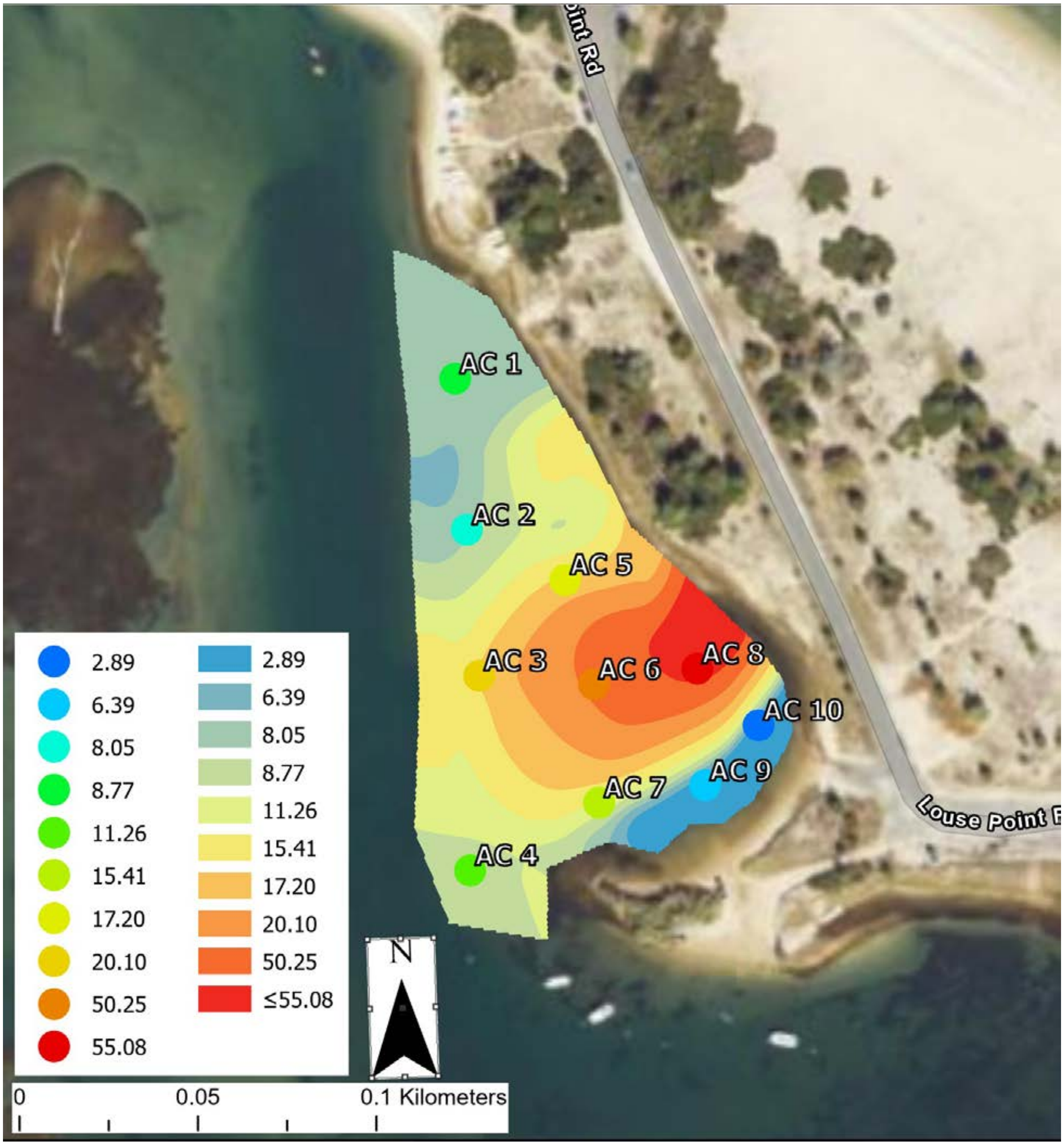


Figure 43. Percent by weight of sediment <90 µm at each site with interpolation in Acabonac Harbor in 2023.

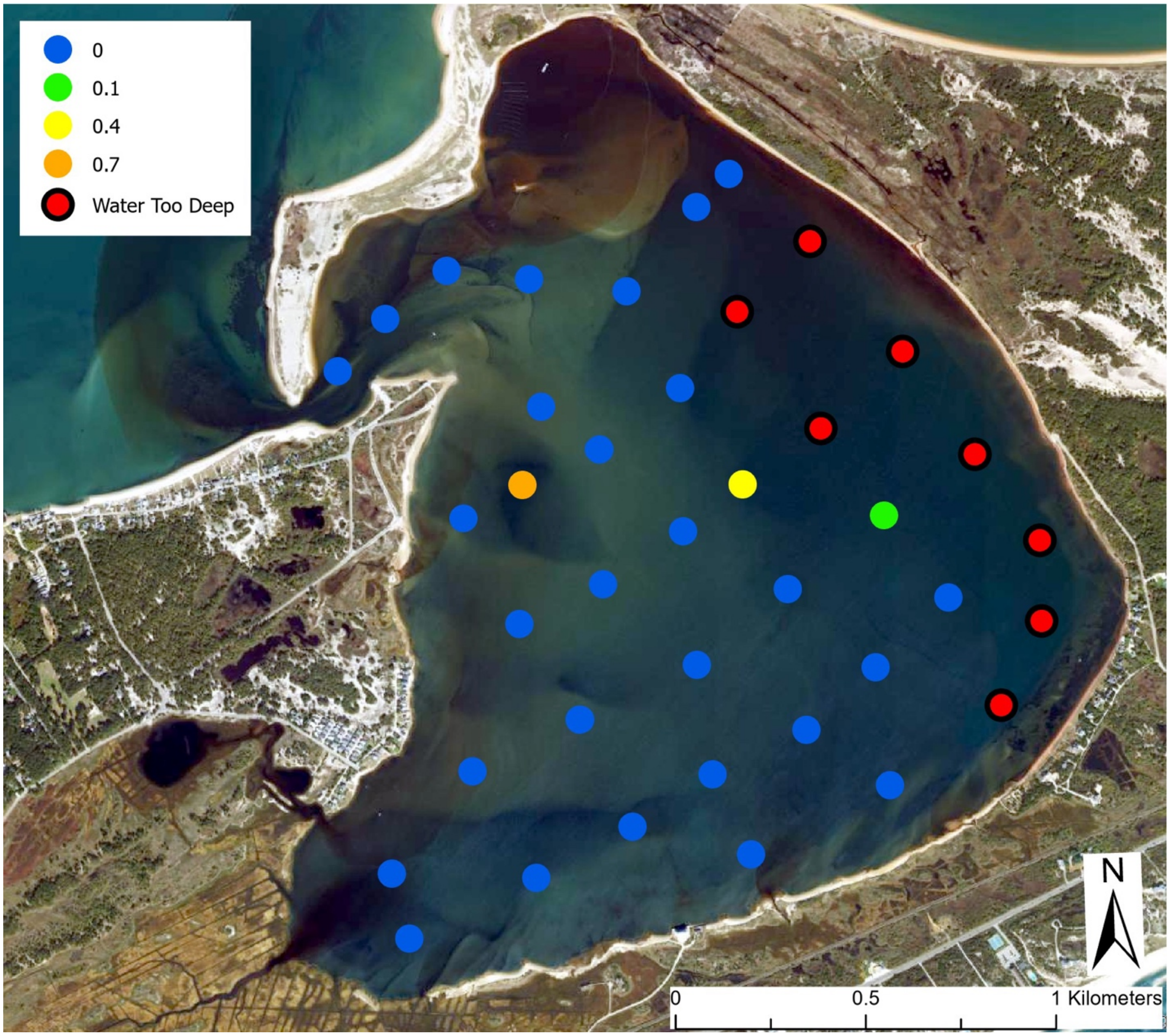


Figure 44. Sediment depth at each site in Napeague Harbor in 2023.

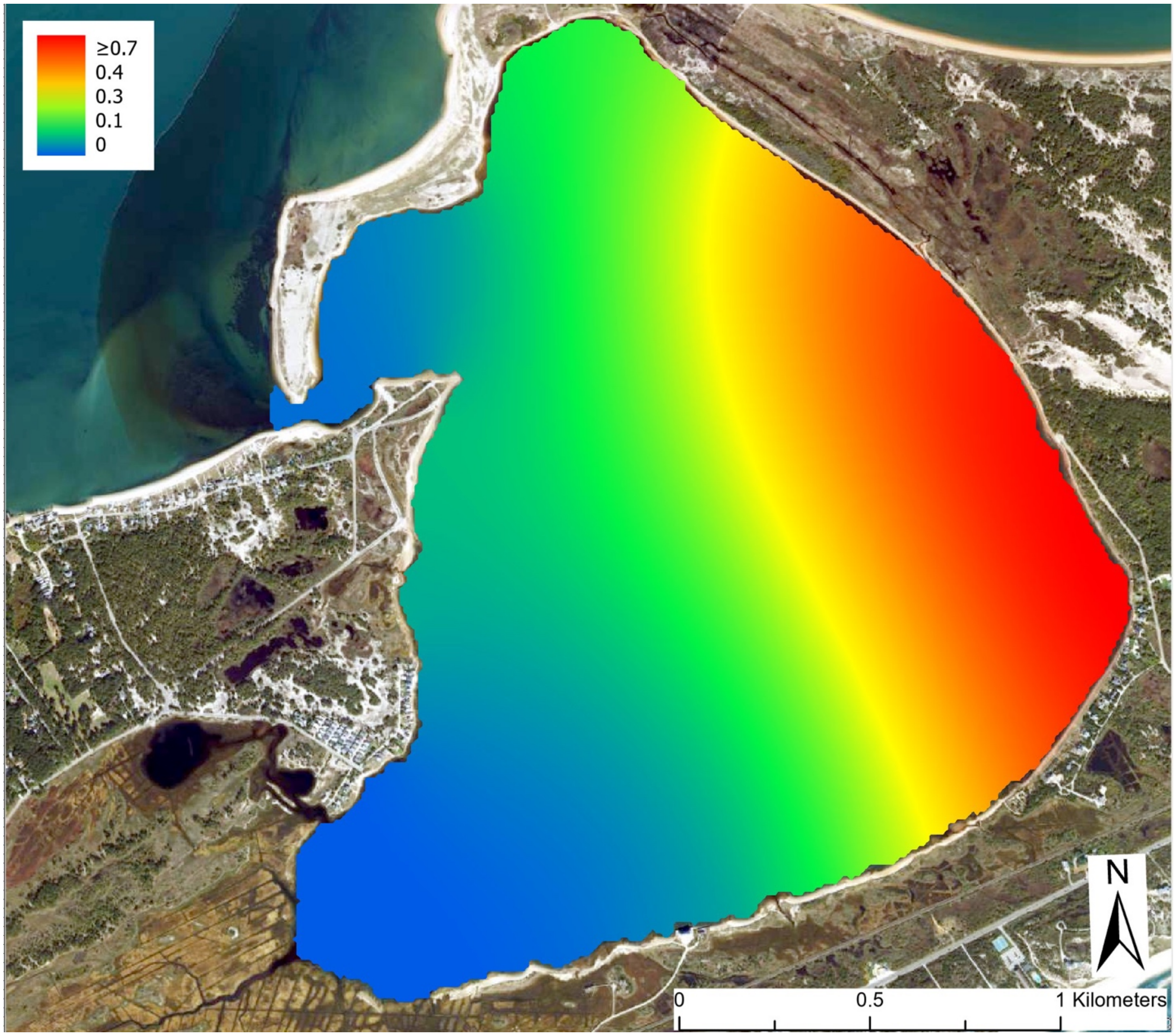


Figure 45. Interpolation of sediment depth at each site in Napeague Harbor in 2023.

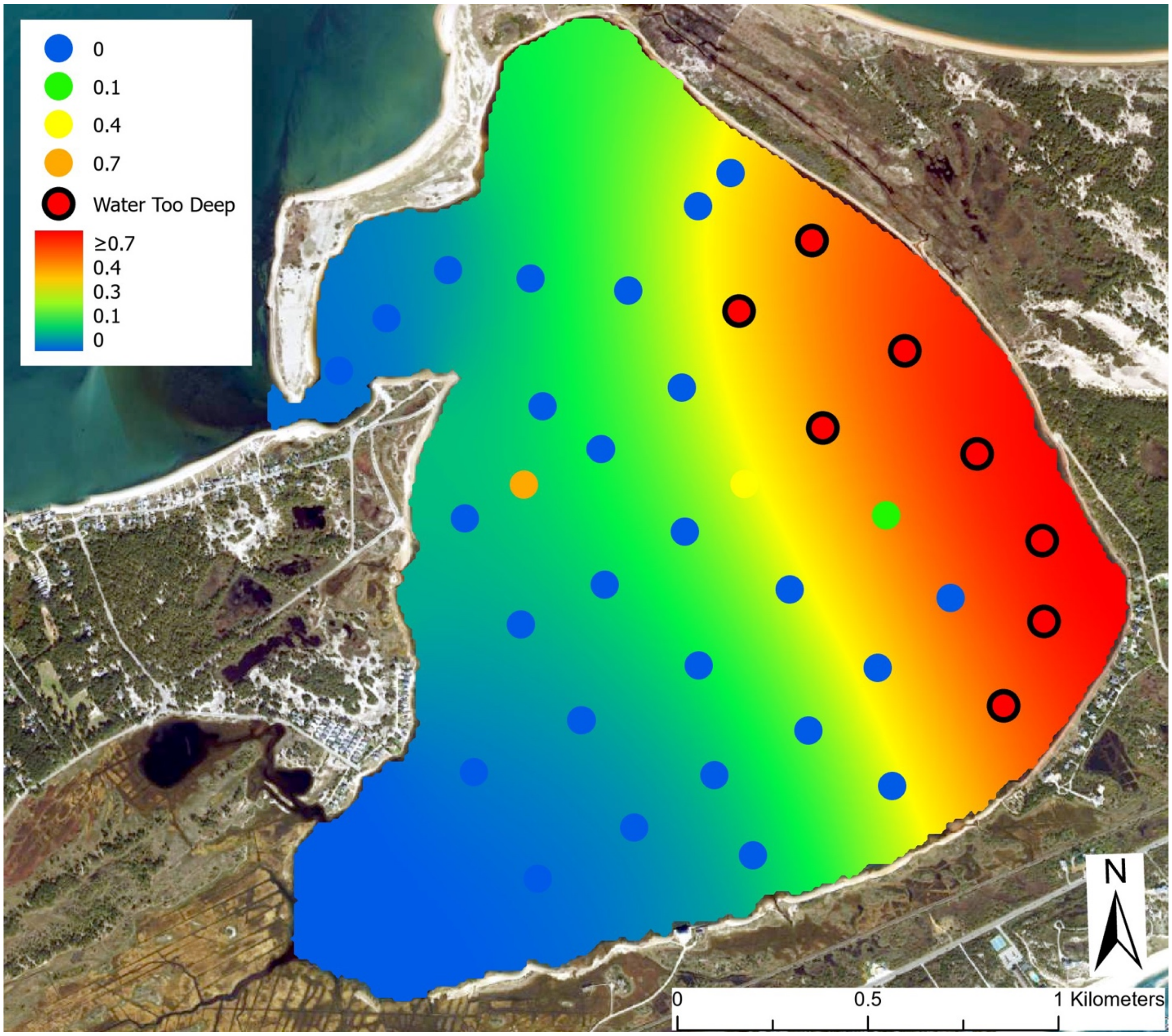


Figure 46. Sediment depth at each site with interpolation in Napeague Harbor in 2023.

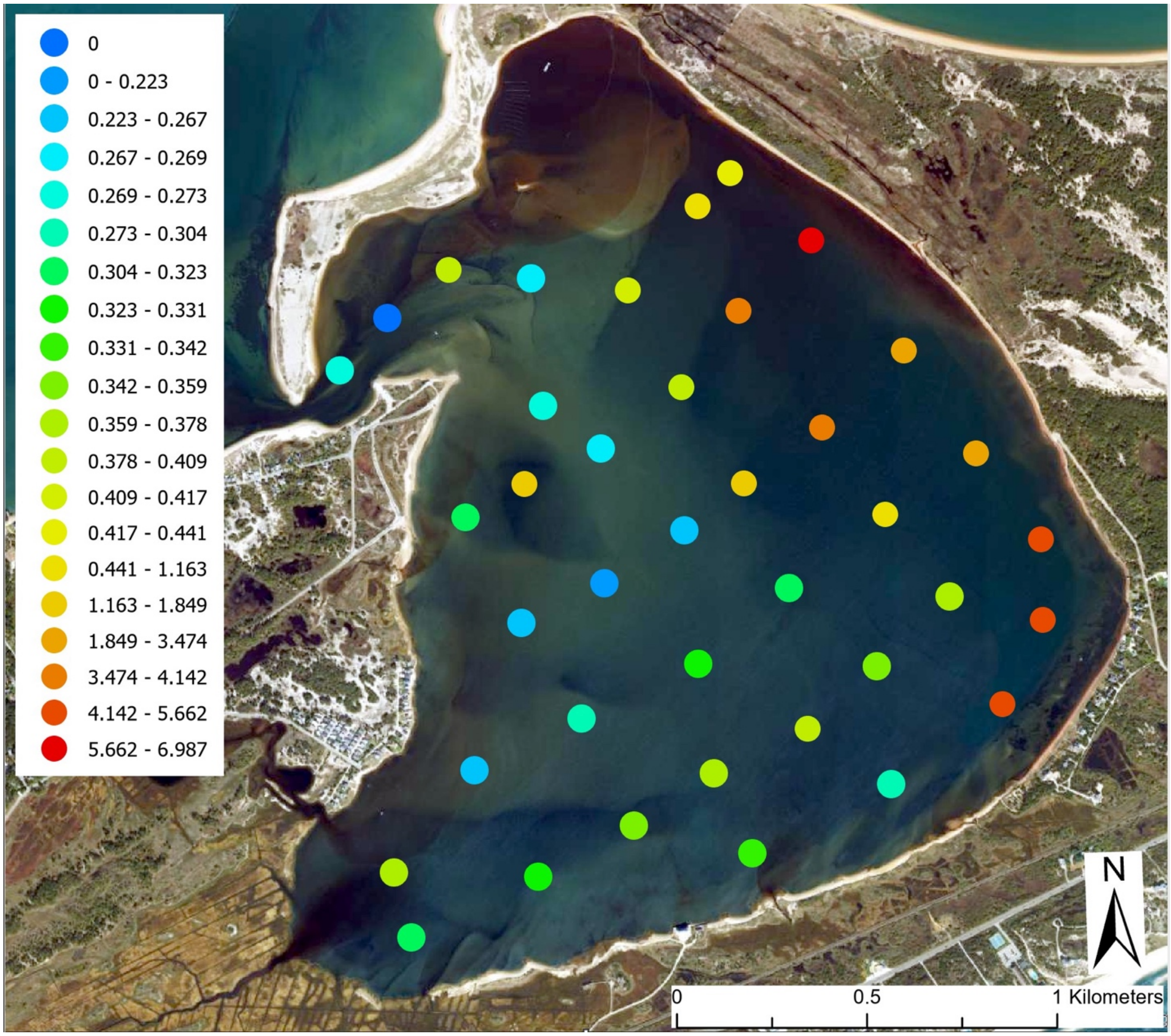


Figure 47. Percent organic matter at each site in Napeague Harbor in 2023.

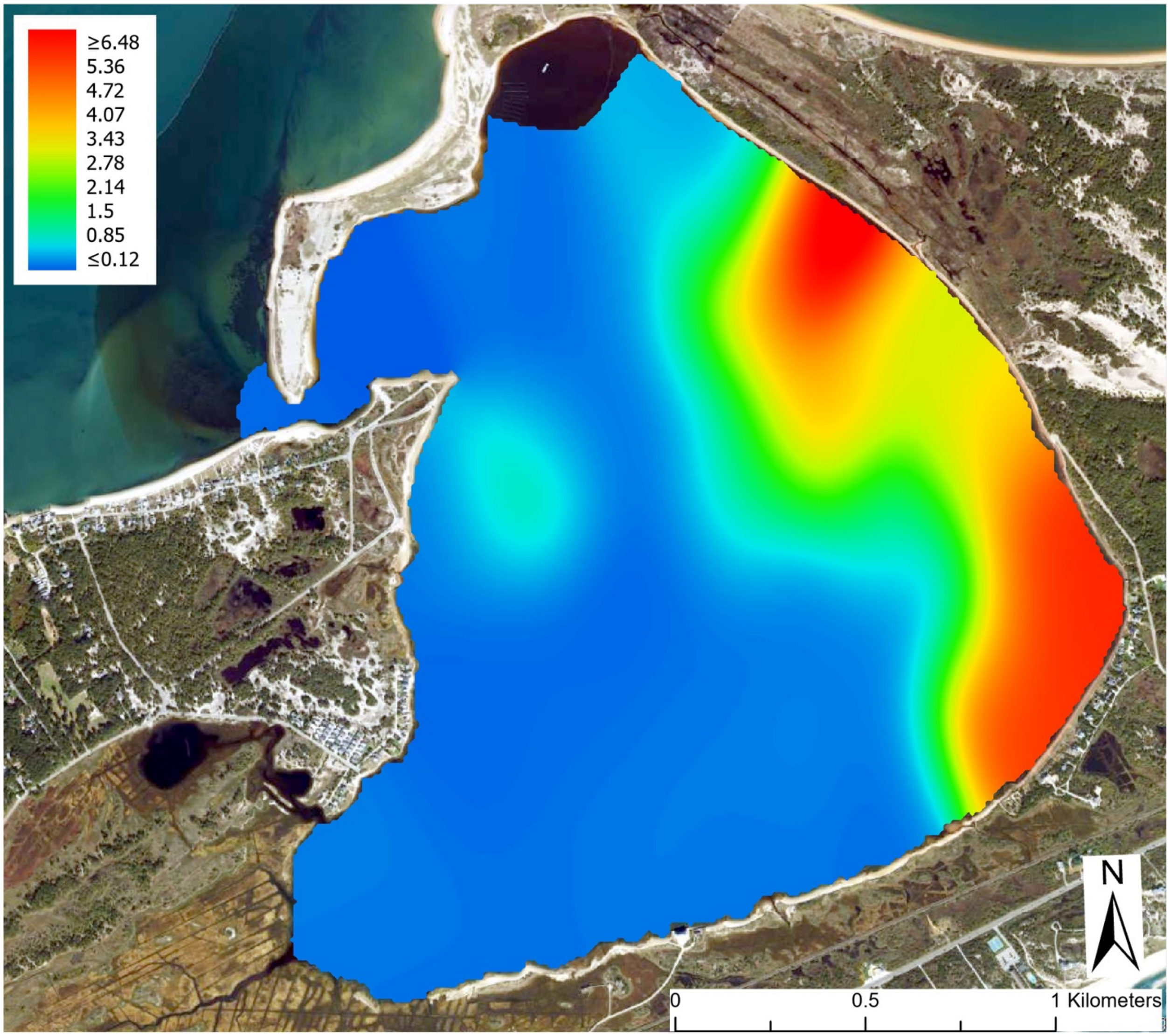


Figure 48. Interpolation of percent organic matter in Napeague Harbor 2023

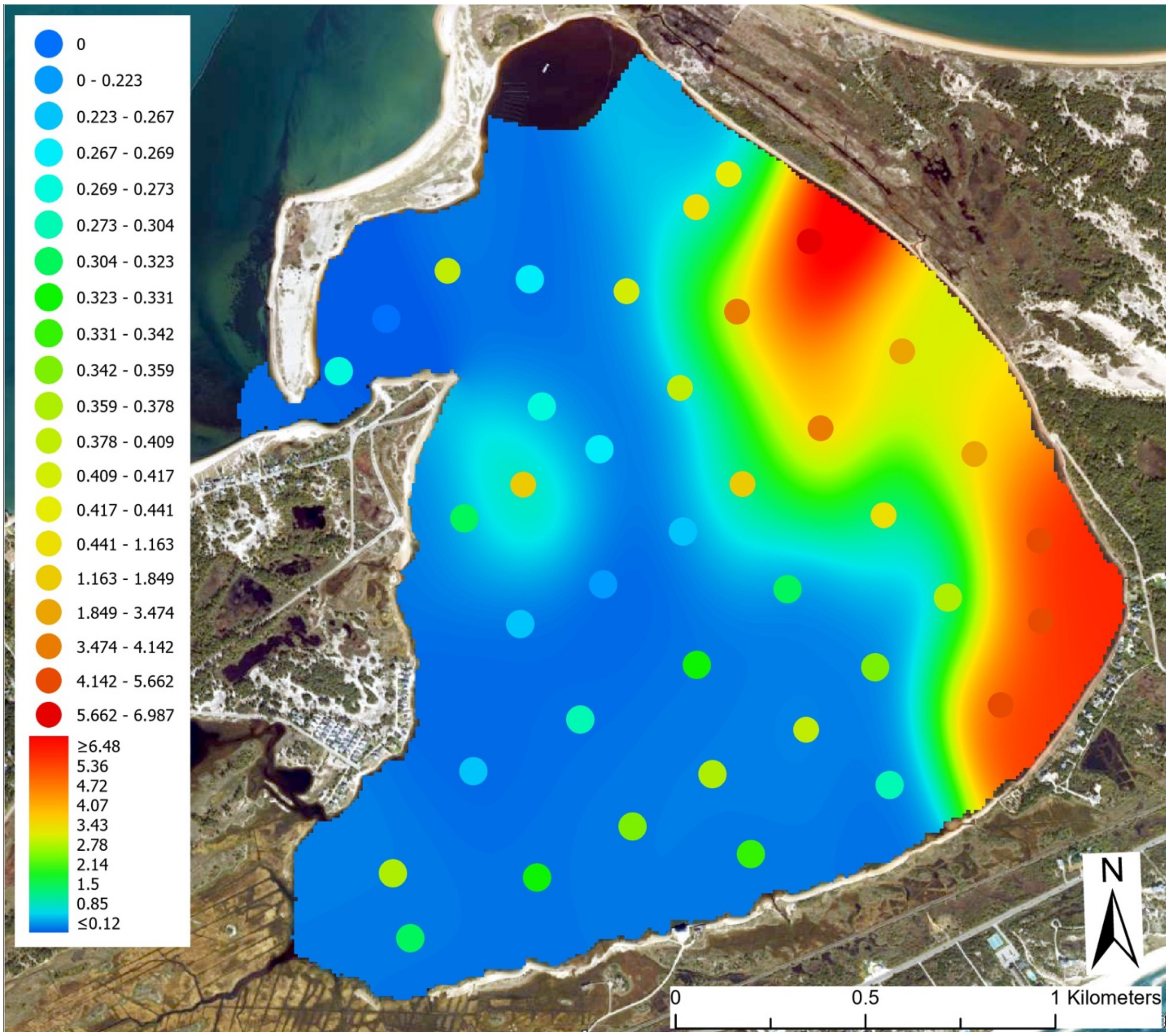


Figure 49. Percent organic matter at each site with interpolation in Napeague Harbor in 2023.

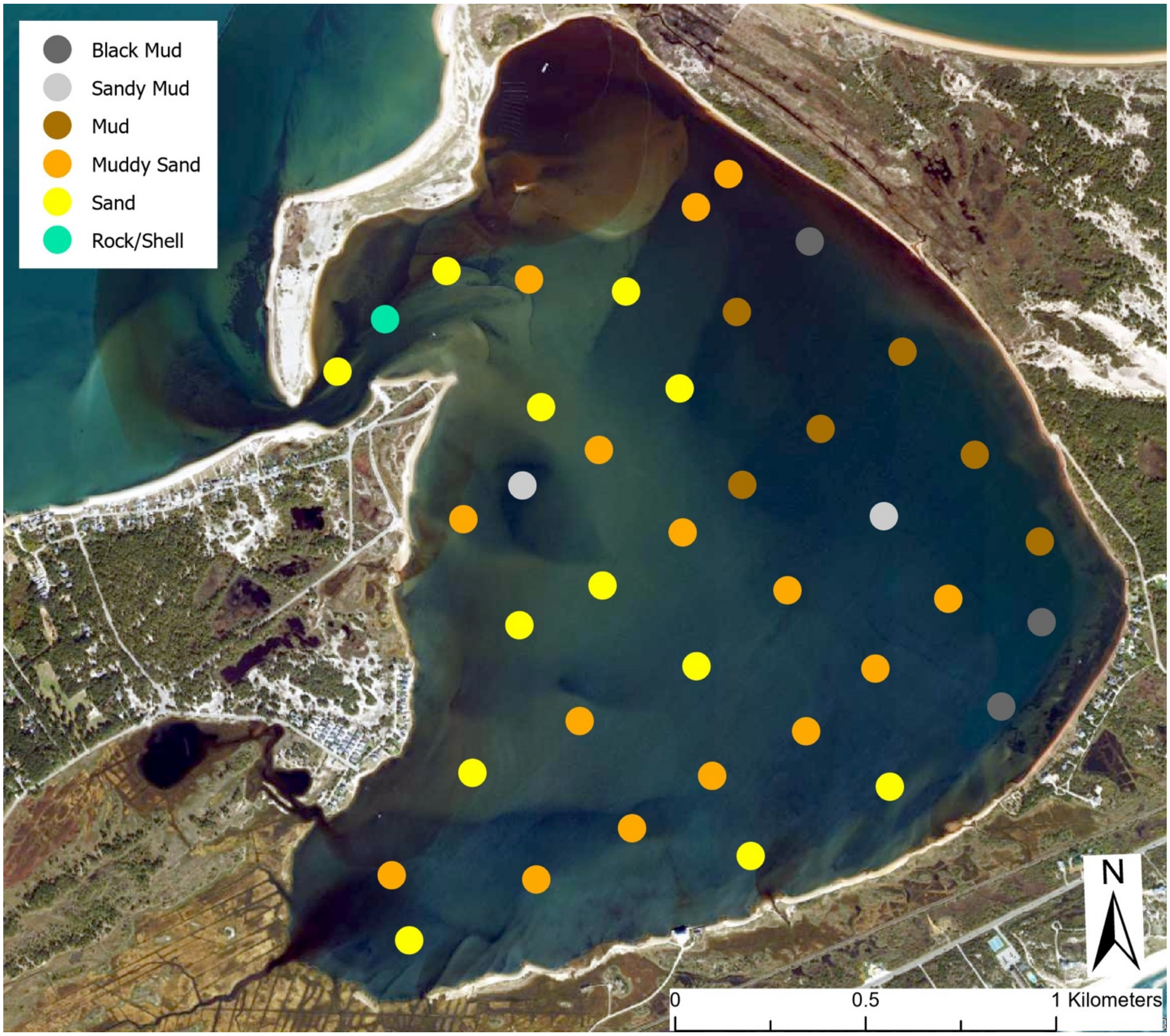


Figure 50. Sediment quality at each site in Napeague Harbor in 2023.

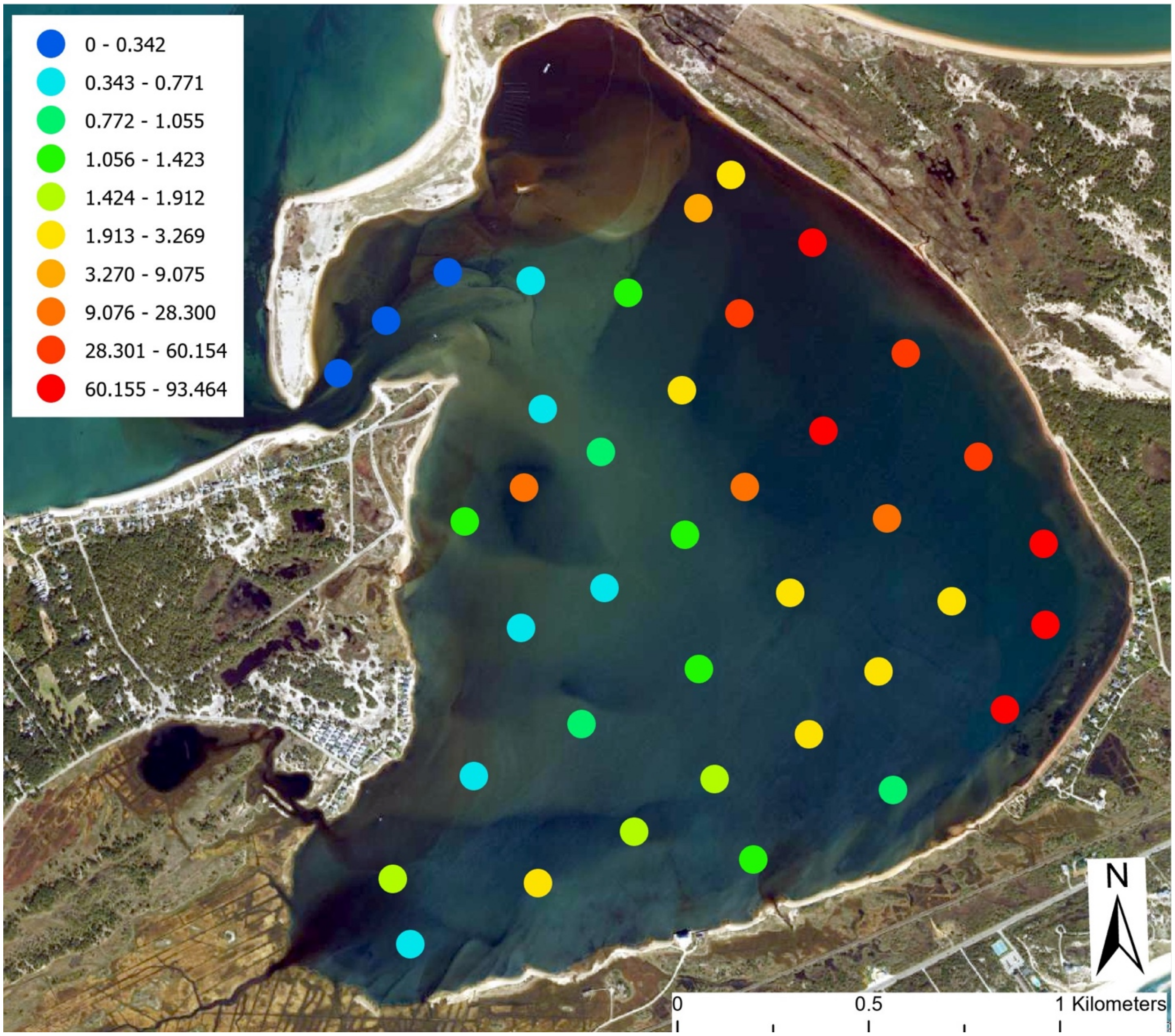


Figure 51. Percent by weight <90 µm at each site in Napeague Harbor in 2023.

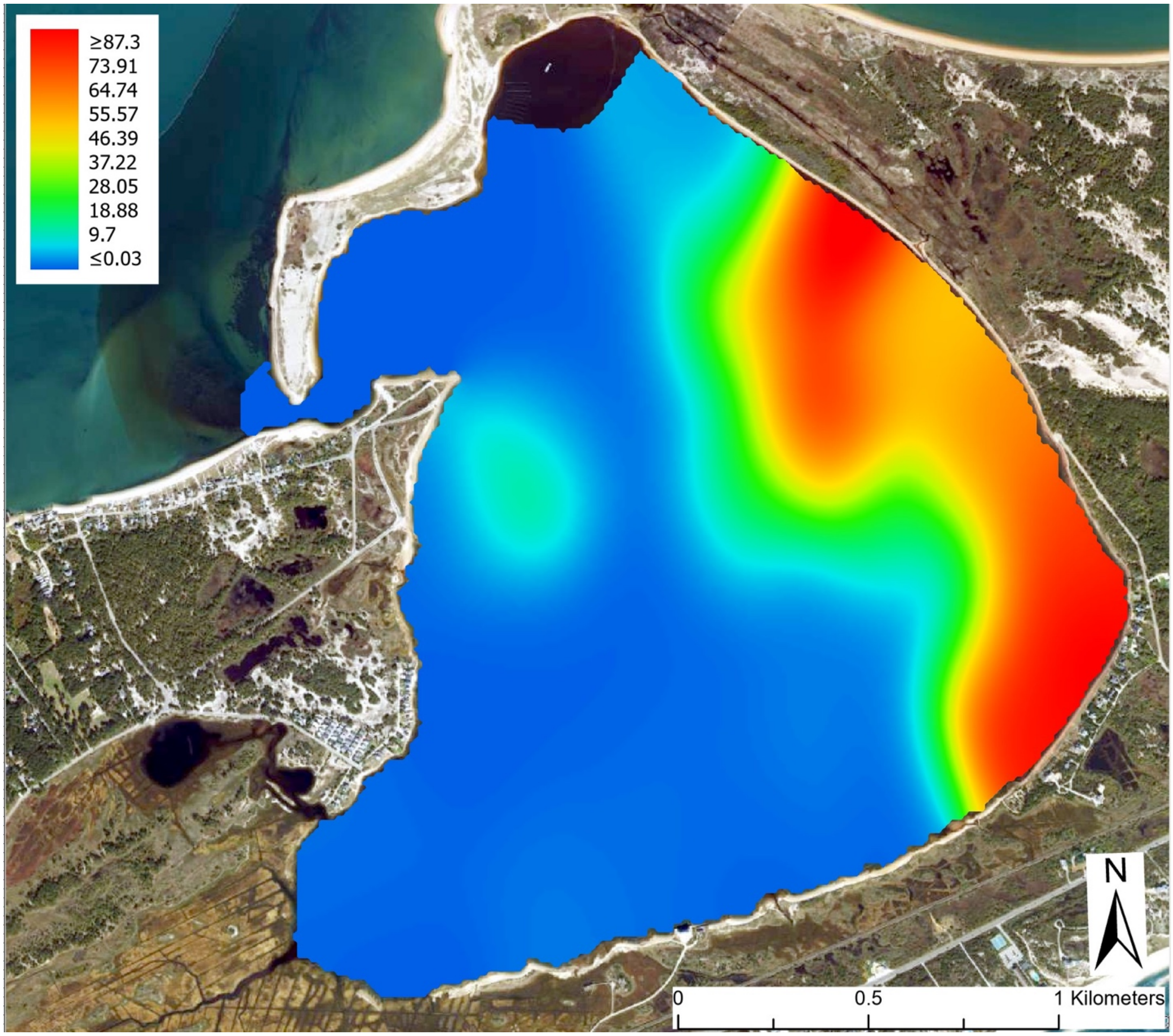


Figure 52. Interpolation of percent by weight <90 µm in Napeague Harbor in 2023.

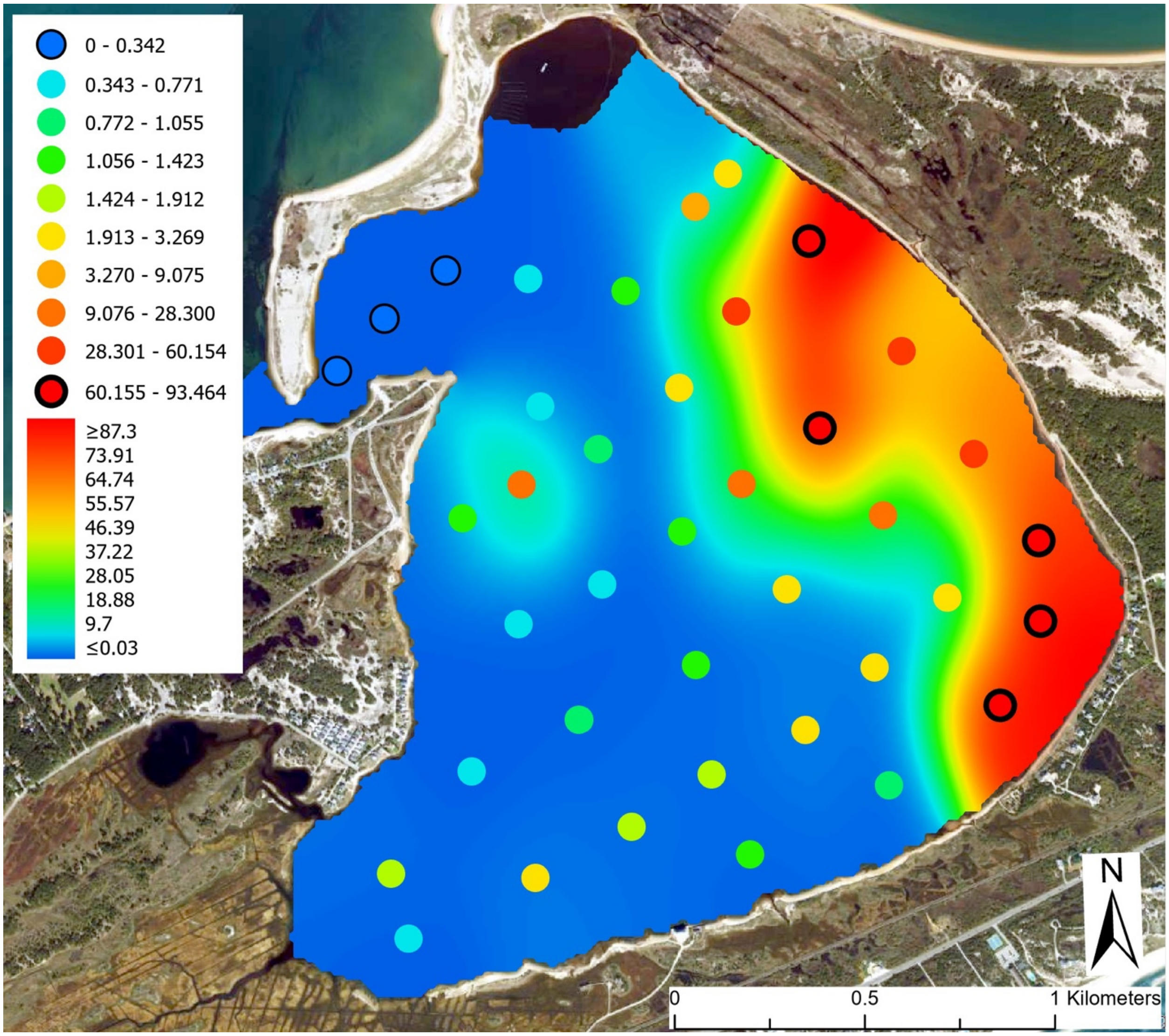


Figure 53. Percent by weight <90 µm at each site with interpolation in Napeague Harbor in 2023.

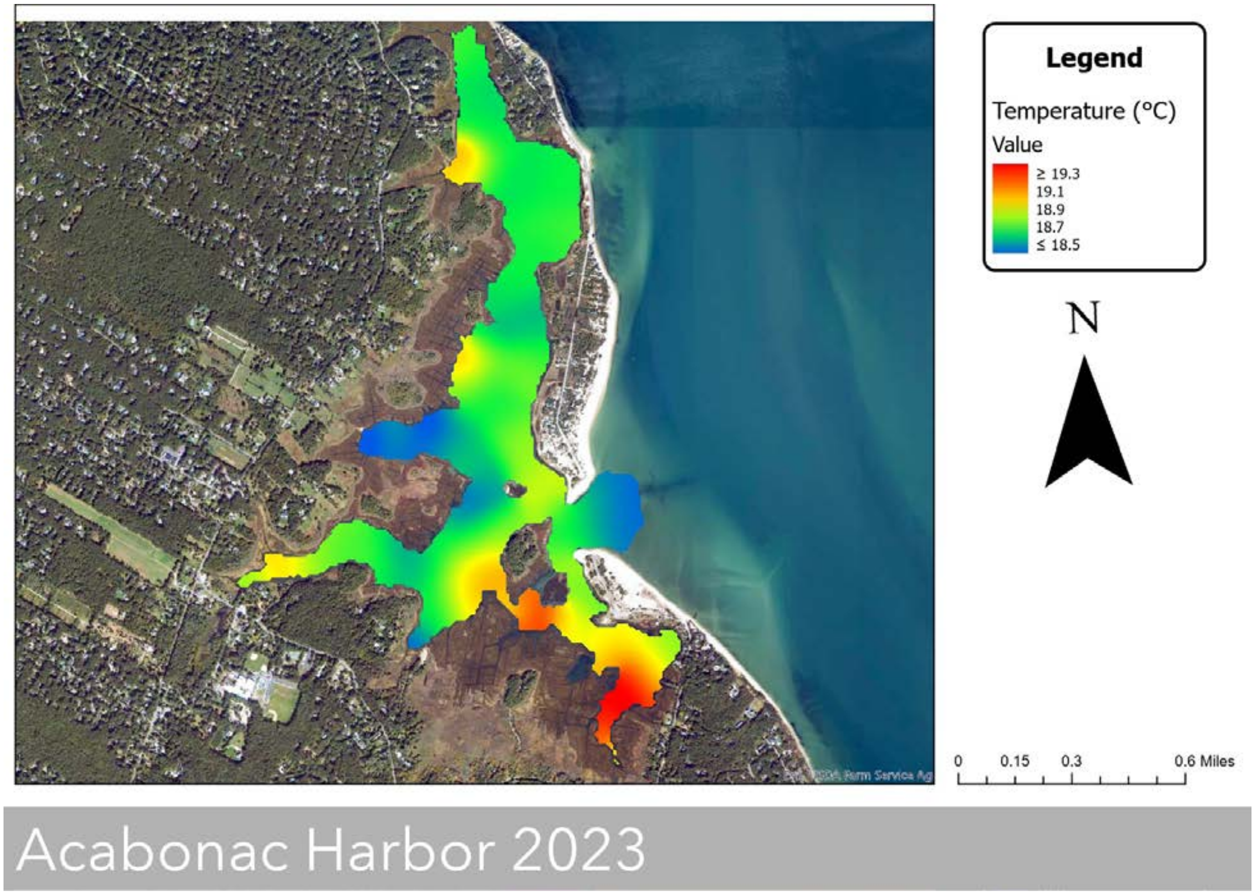


Figure 54. Temperature (°C) measurements taken across Acabonac Harbor during October 2023 by the HYCAT autonomous surface vehicle.

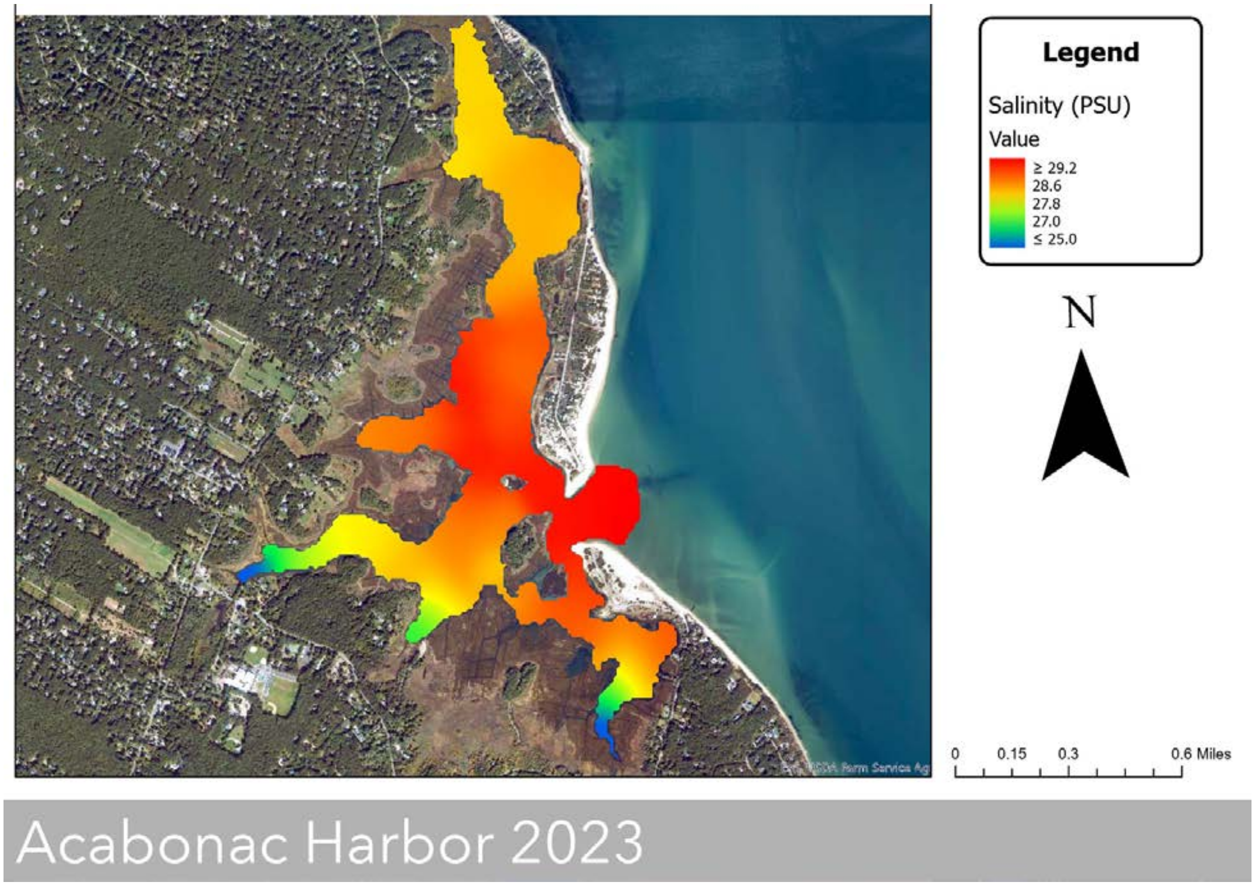


Figure 55. Salinity (PSU) measurements taken across Acabonac Harbor during October 2023 by the HYCAT autonomous surface vehicle.

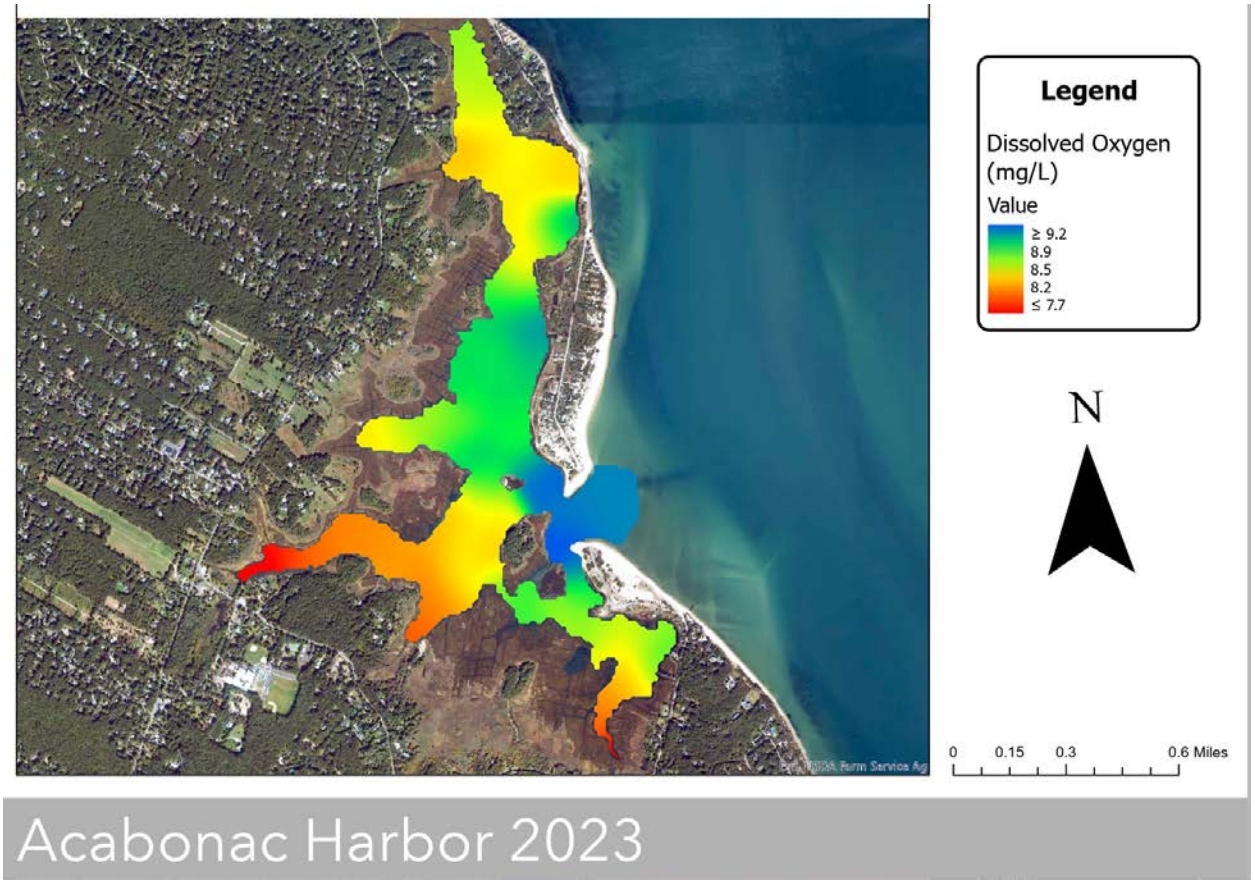


Figure 56. Dissolved oxygen (mg/L) measurements taken across Acabonac Harbor during October 2023 by the HYCAT autonomous surface vehicle.

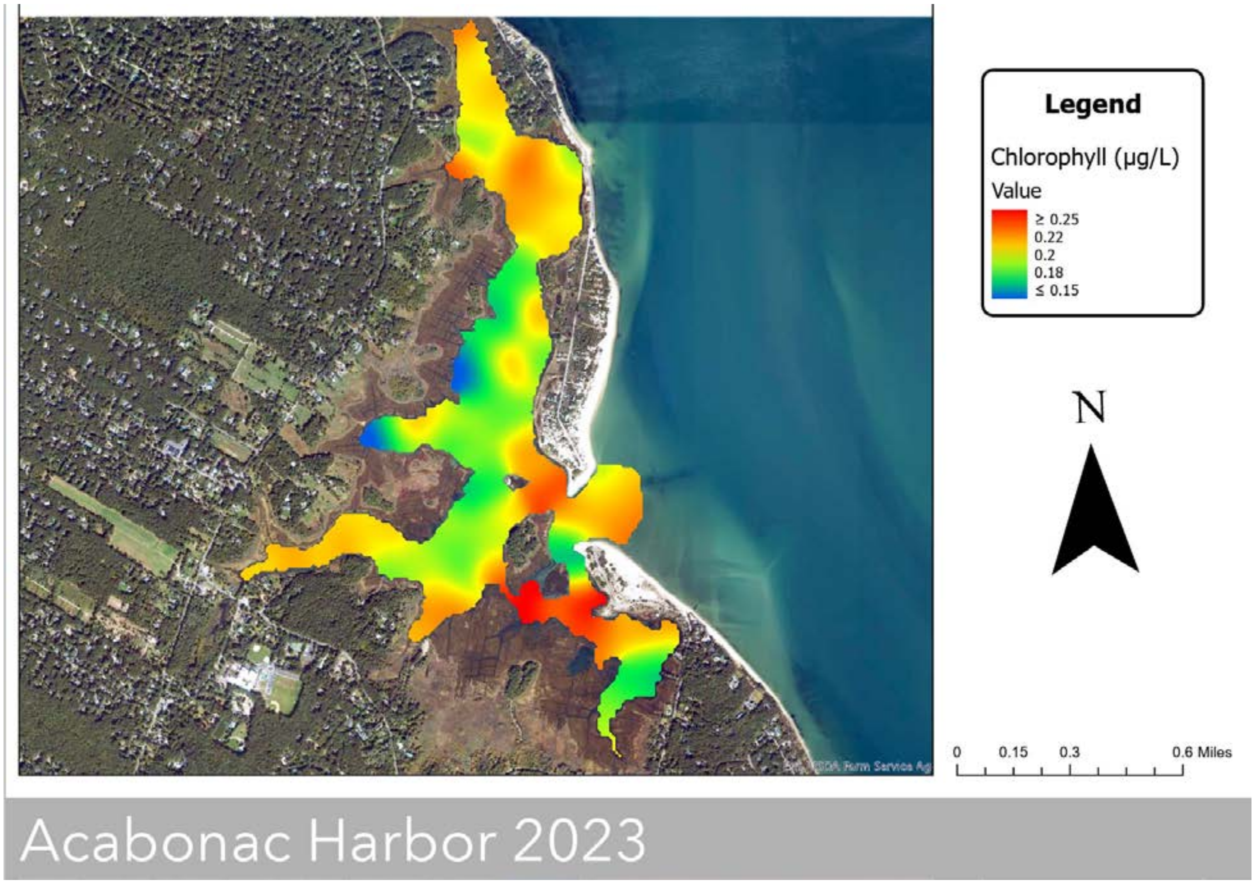


Figure 57. Chlorophyll-a (µg/L) measurements taken across Acabonac Harbor during October 2023 by the HYCAT autonomous surface vehicle.

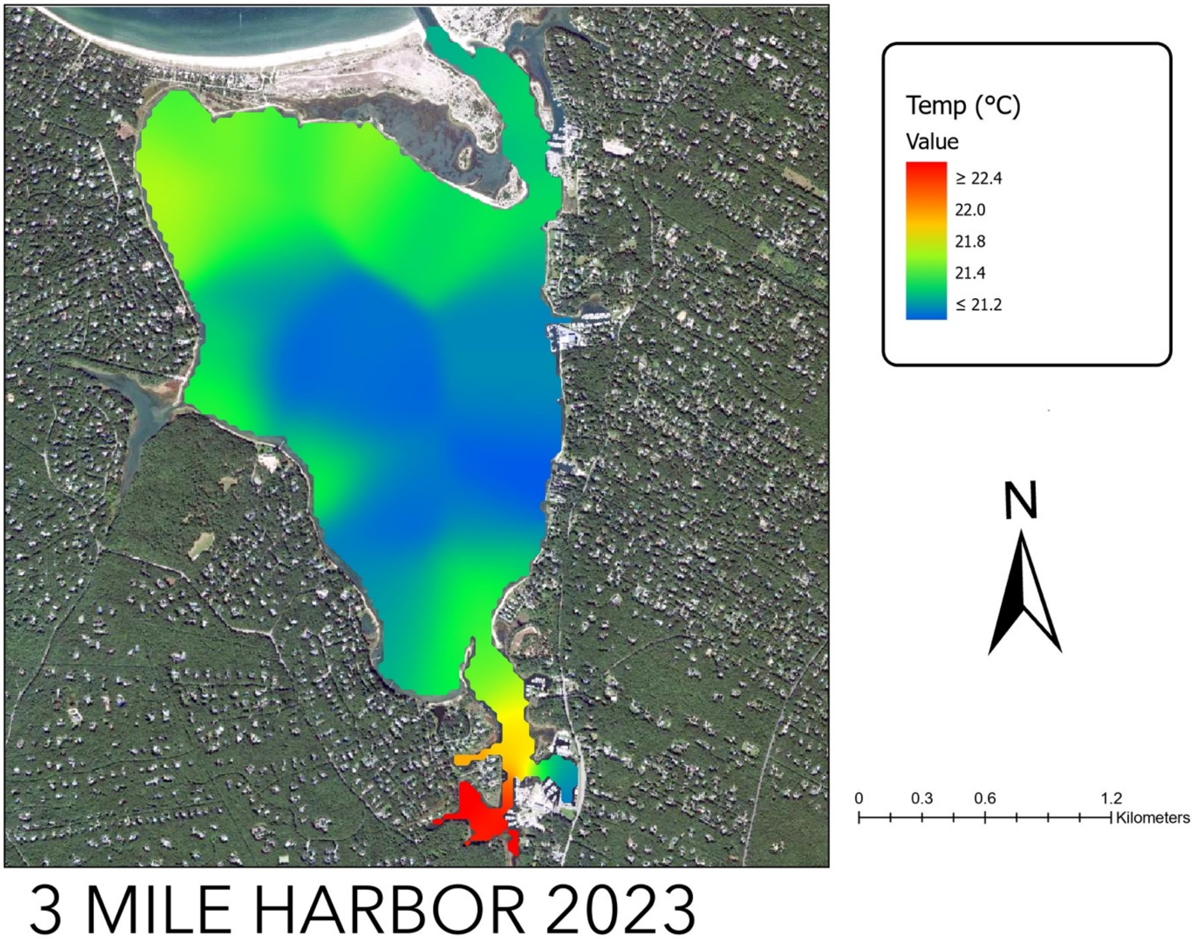


Figure 58. Temperature (°C) measurements taken across Three Mile Harbor during October 2023 by the HYCAT autonomous surface vehicle.

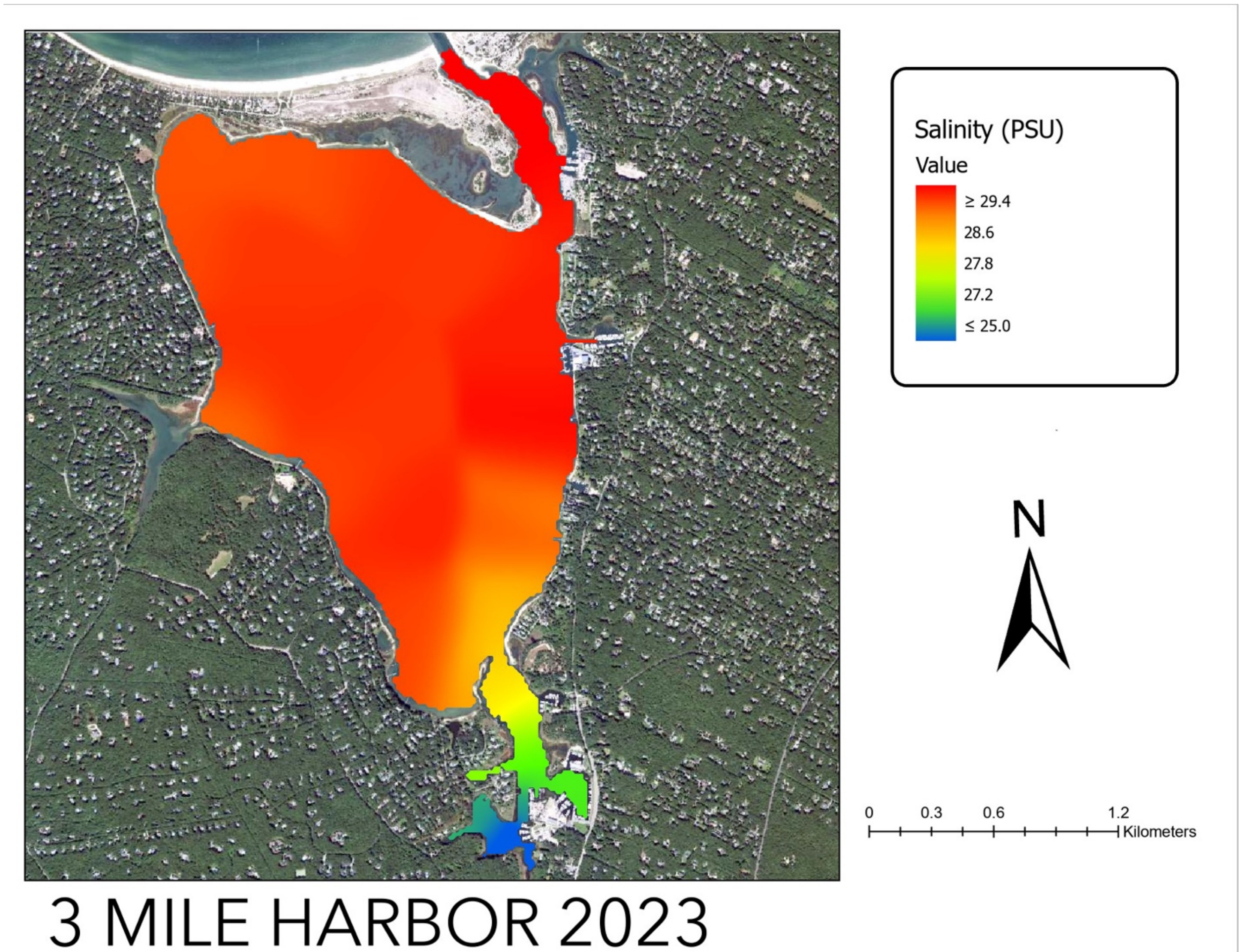


Figure 59. Salinity (PSU) measurements taken across Three Mile Harbor during October 2023 by the HYCAT autonomous surface vehicle.

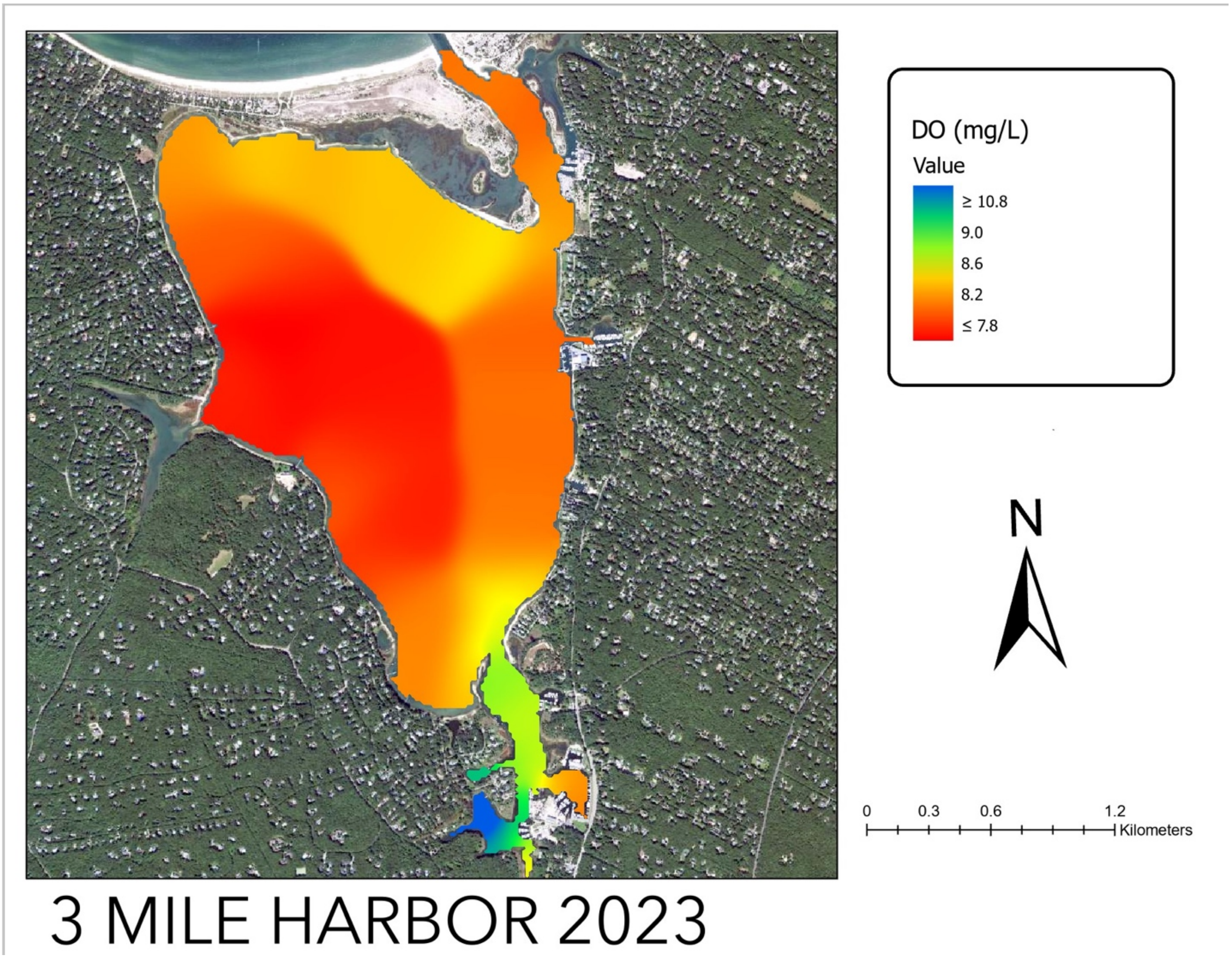


Figure 60. Dissolved oxygen (mg/L) measurements taken across Three Mile Harbor during October 2023 by the HYCAT autonomous surface vehicle.

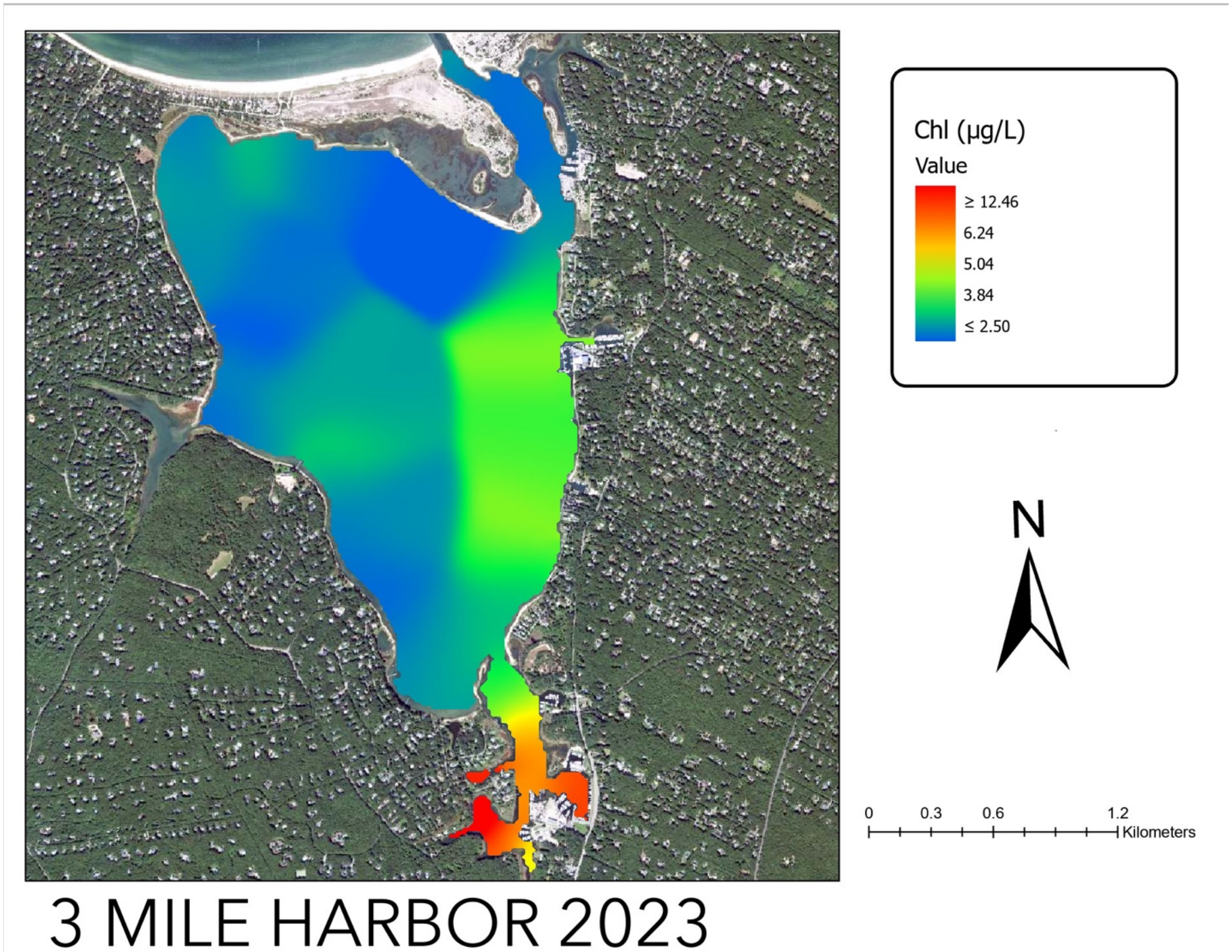


Figure 61. Chlorophyll-a (µg/L) measurements taken across Three Mile Harbor during October 2023 by the HYCAT autonomous surface vehicle.

High Tide 9/22/23 1:40PM Start

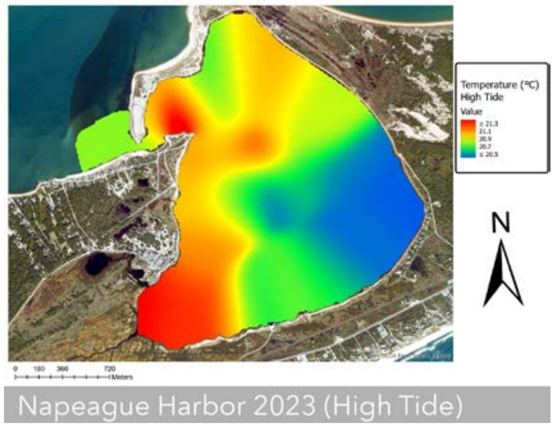


Figure 62. Temperature (°C) measurements taken across Napeague Harbor on 22-September-2023, by the HYCAT autonomous surface vehicle.

High Tide 9/22/23 1:40PM Start **Low Tide 9/22/23 7:20AM Start**

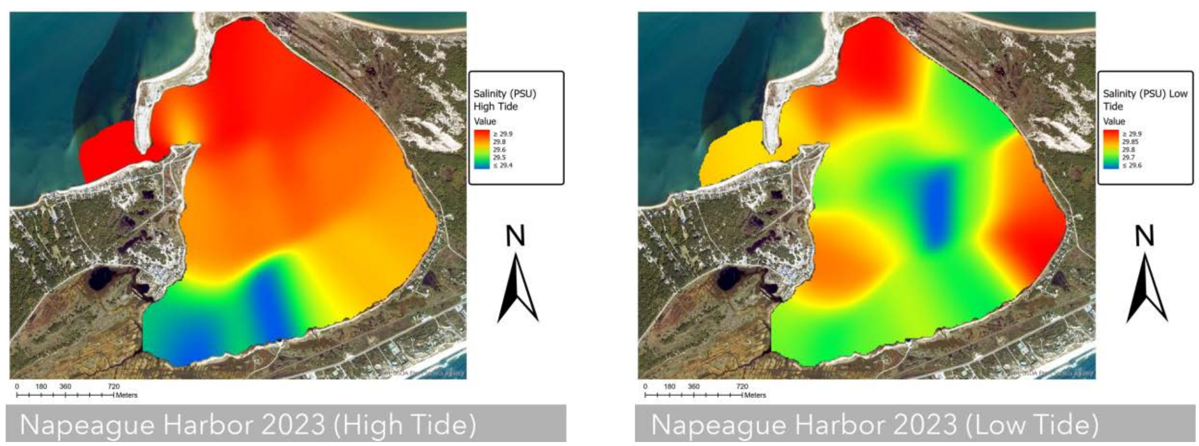


Figure 63. Salinity (PSU) measurements taken across Napeague Harbor on 22-September-2023, by the HYCAT autonomous surface vehicle.

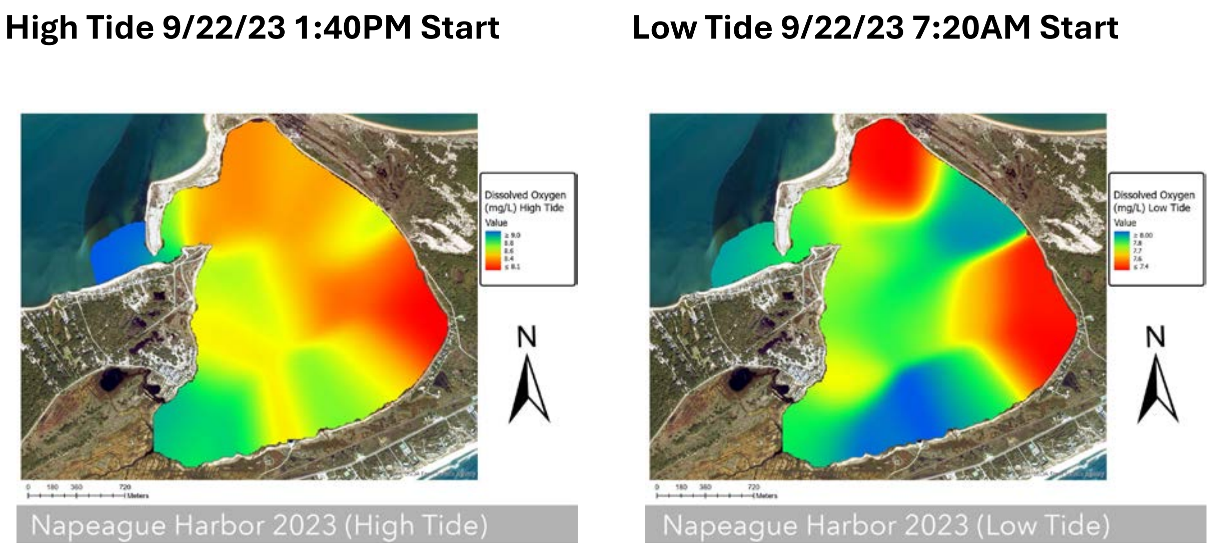


Figure 64. Dissolved oxygen (mg/L) measurements taken across Napeague Harbor on 22-September-2023, by the HYCAT autonomous surface vehicle.

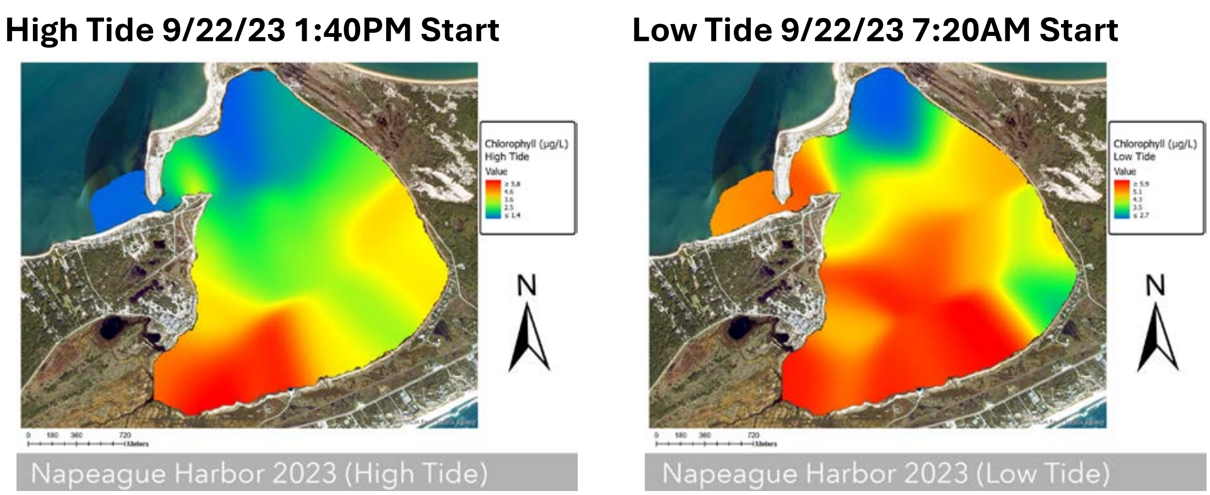


Figure 65. Chlorophyll-a (µg/L) measurements taken across Napeague Harbor on 22-September-2023, by the HYCAT autonomous surface vehicle.

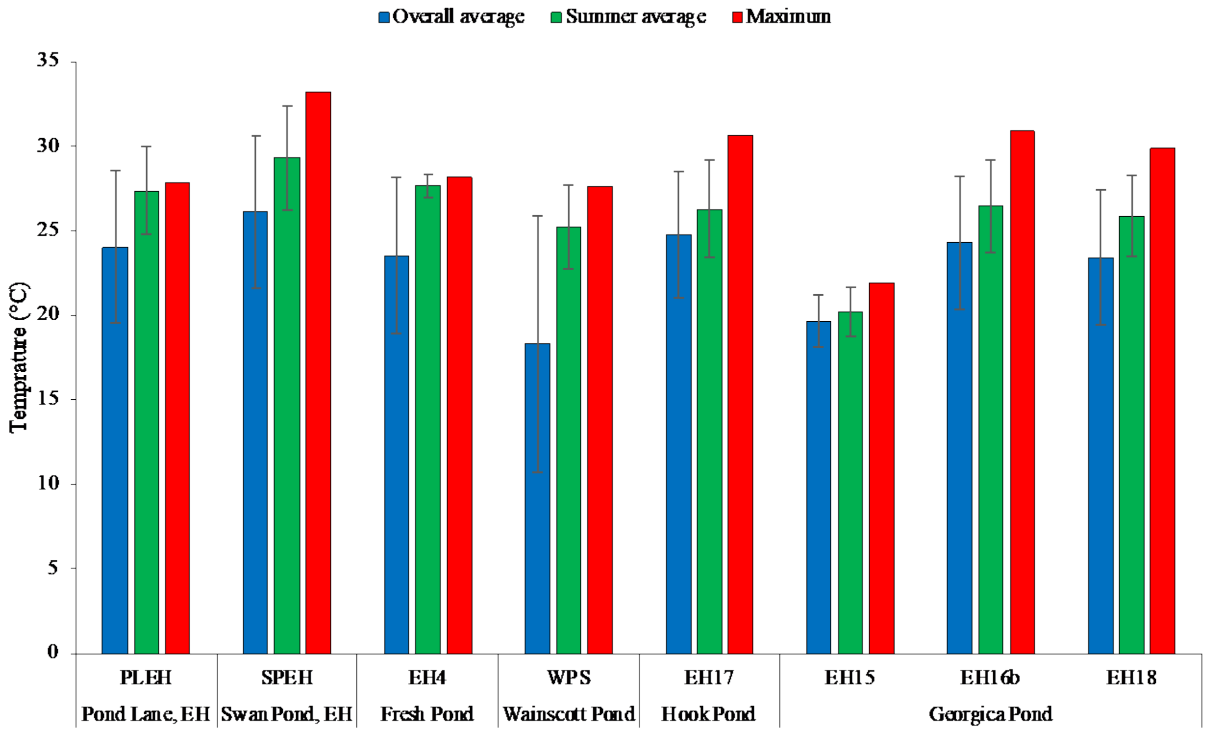


Figure 66. Overall average, summer average, and maximum surface water temperatures (°C) at freshwater sites in East Hampton during 2023. Error bars represent standard deviation.

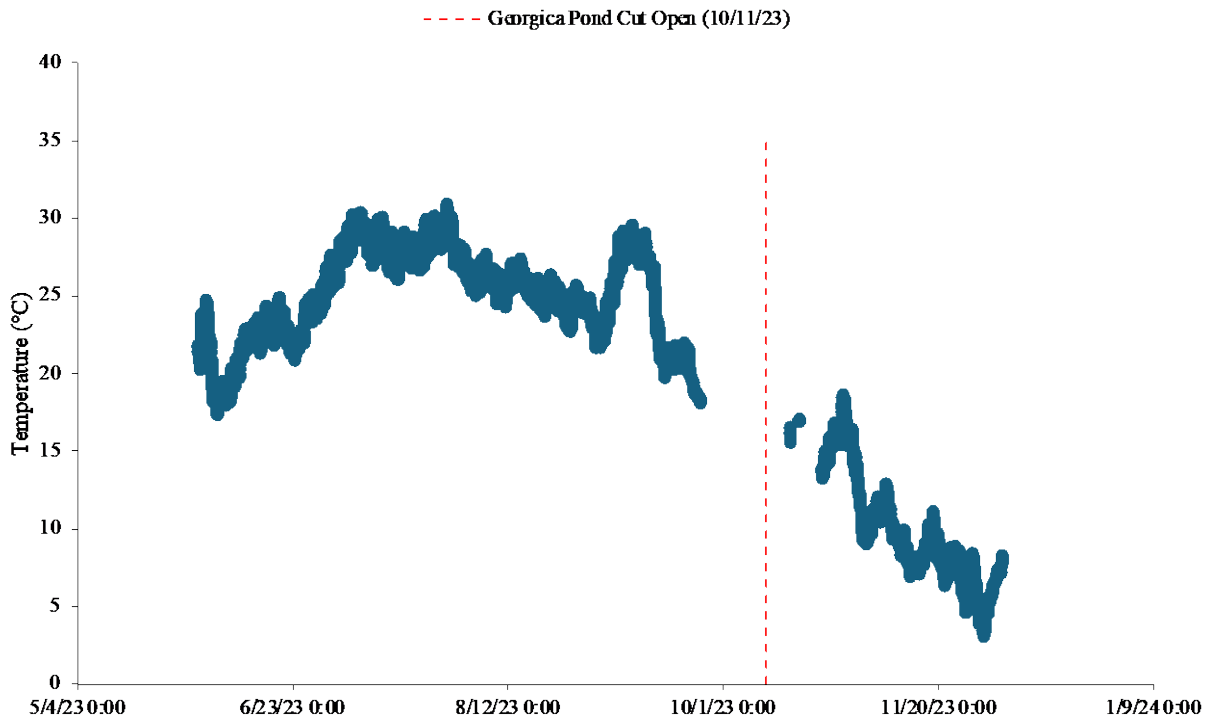


Figure 67. Continuous surface water temperatures (°C) at the buoy in Georgica Pond during 2023. The vertical dashed line represents when the ocean inlet in the south of Georgica Pond was opened on 11-October-2023. Gaps in graph were when sensors were malfunctioning, and no data was recorded.

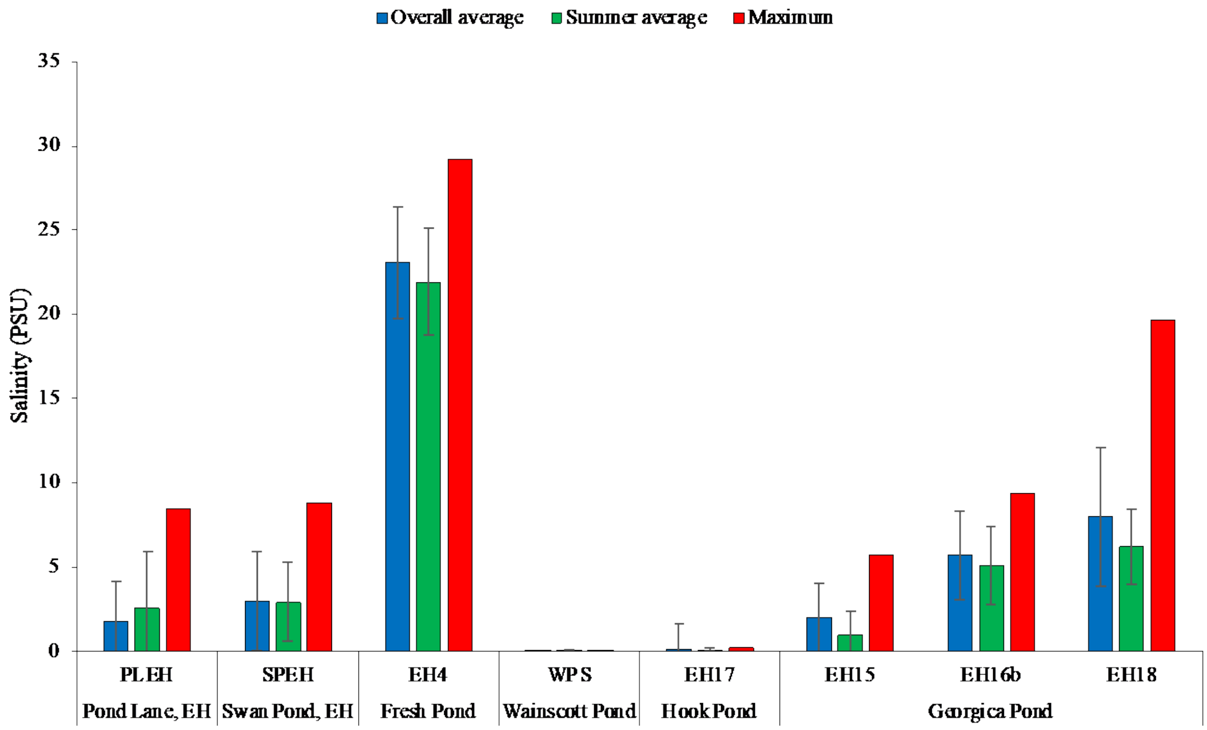


Figure 68. Overall average, summer average, and maximum surface water salinities (PSU) at freshwater sites in East Hampton during 2023. Error bars represent standard deviation.

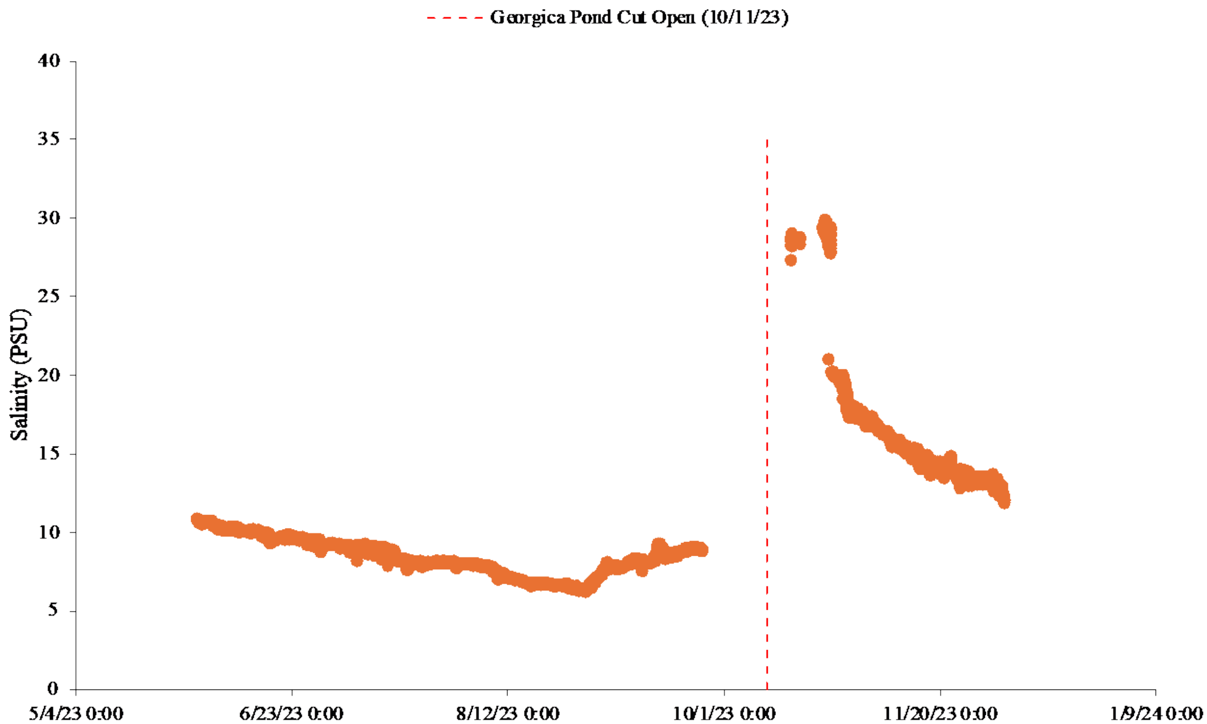


Figure 69. Continuous surface water salinity (PSU) at the buoy in Georgica Pond during 2023. The vertical dashed line represents when the ocean inlet in the south of Georgica Pond was opened on 11-October-2023. Gaps in graph were when sensors were malfunctioning, and no data was recorded.

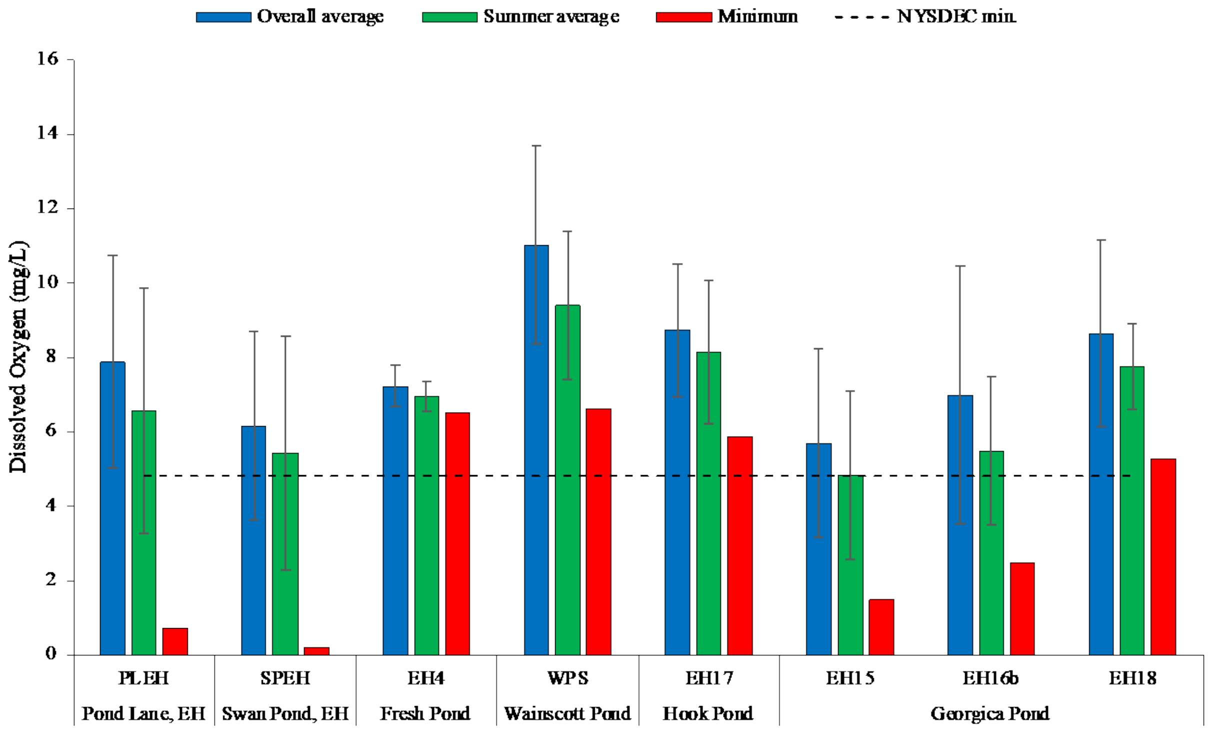


Figure 70. Overall average, summer average, and minimum surface water dissolved oxygen concentrations (mg/L) at freshwater sites in East Hampton during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). Error bars represent standard deviation.

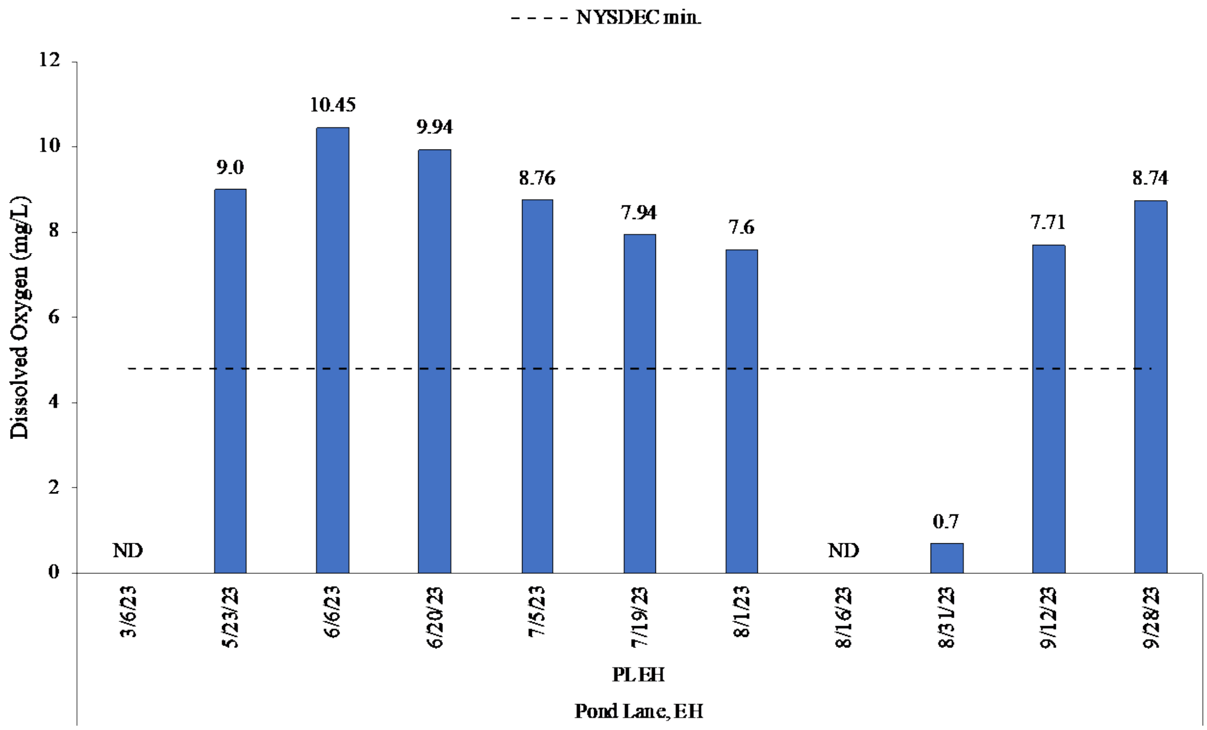


Figure 71. Surface water dissolved oxygen concentrations (mg/L) at Pond Lane, EH (PLEH) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). ND = No data collected for the date.

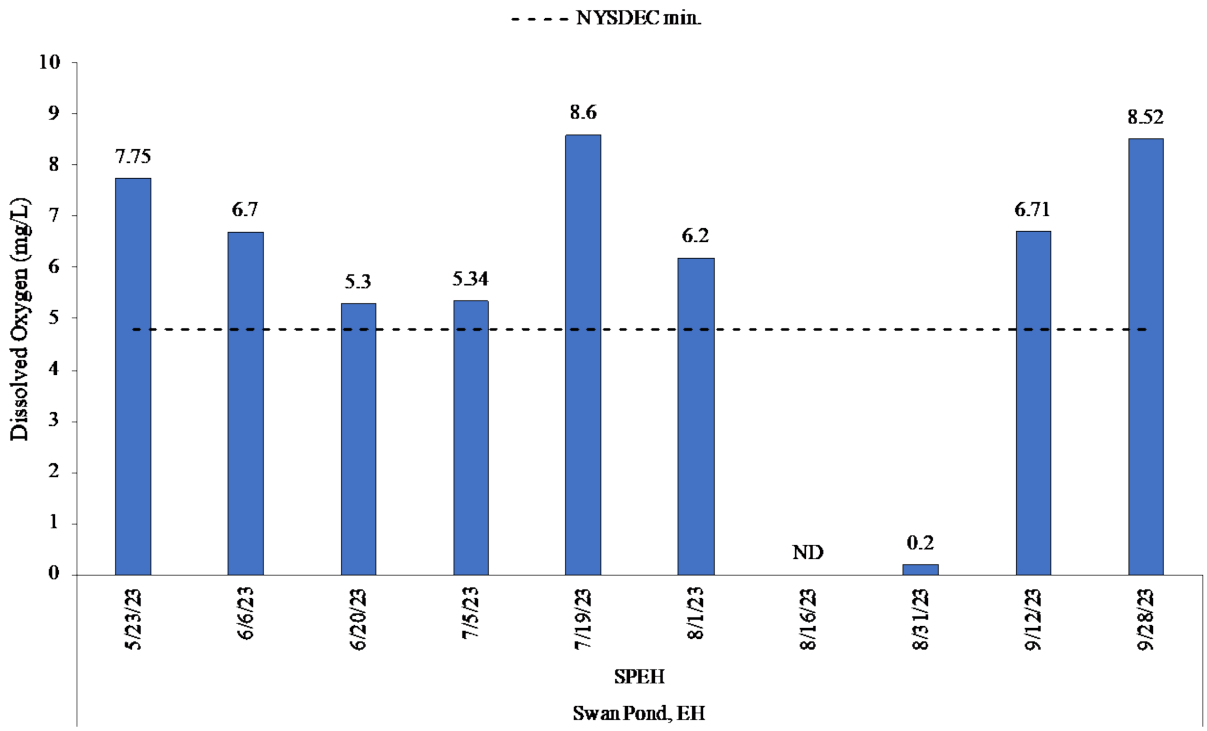


Figure 72. Surface water dissolved oxygen concentrations (mg/L) at Swan Pond, EH (SPEH) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). ND = No data collected for the date.

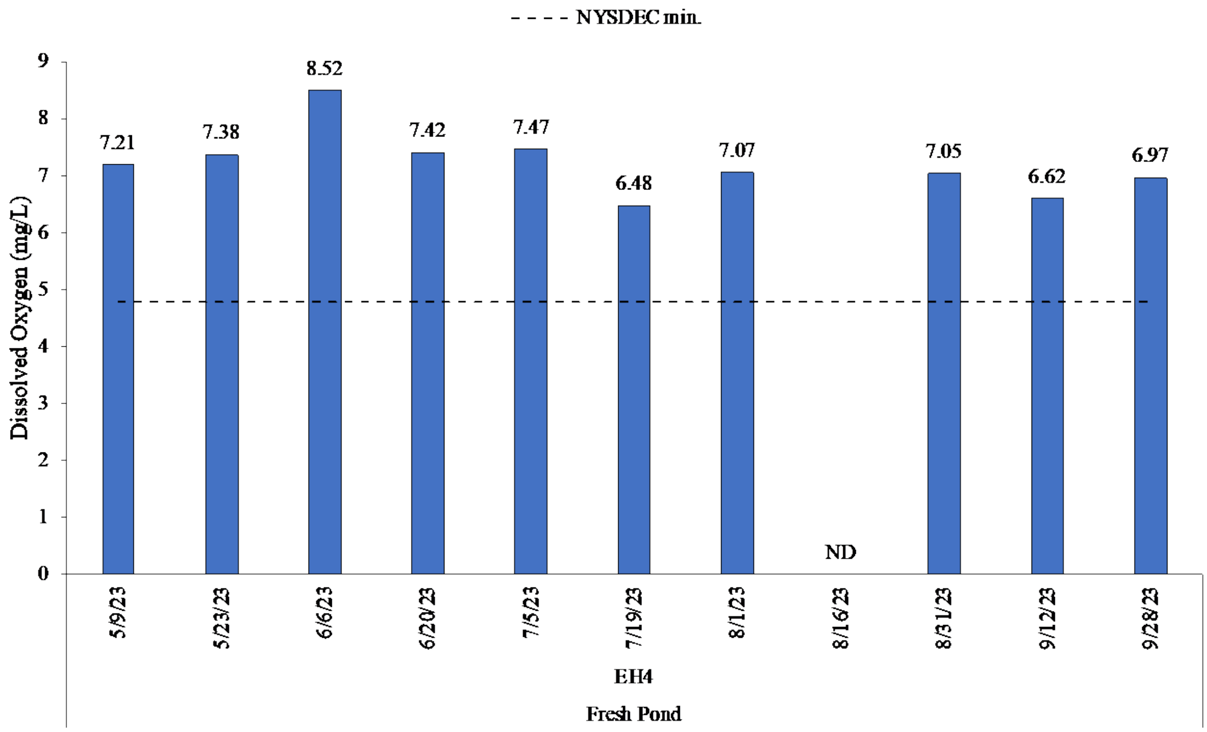


Figure 73. Surface water dissolved oxygen concentrations (mg/L) at Fresh Pond (EH4) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). ND = No data collected for the date.

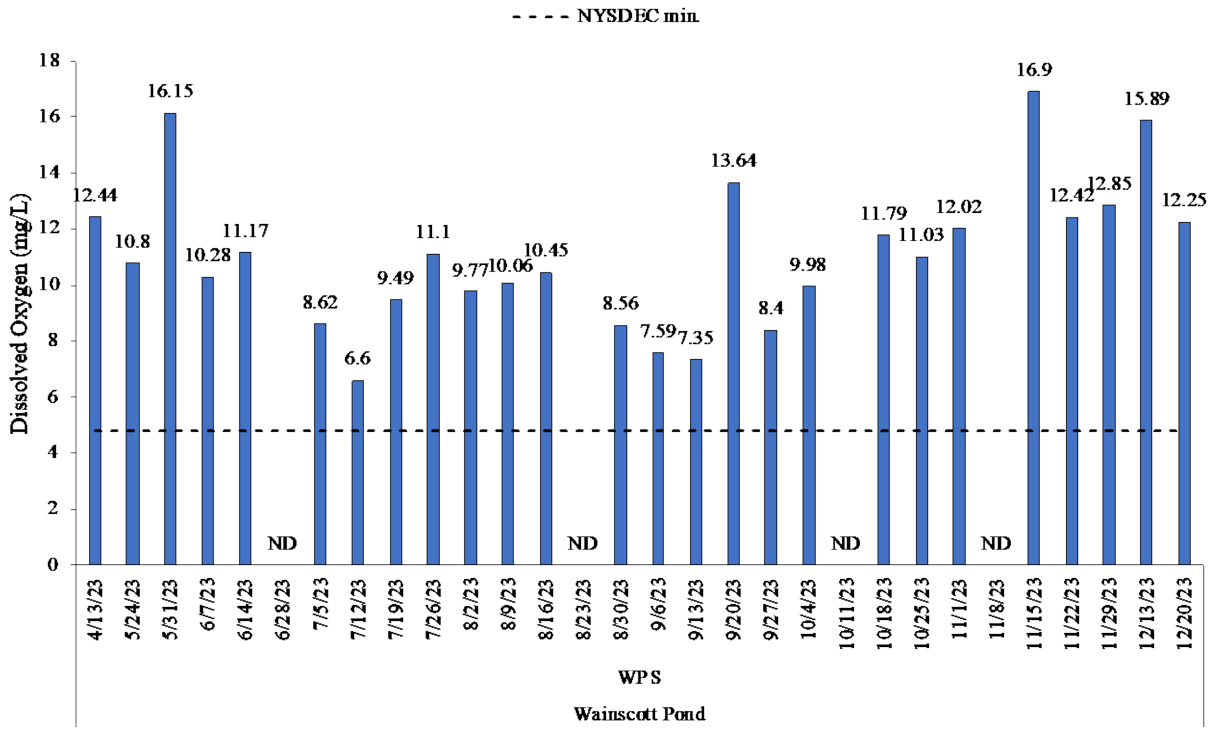


Figure 74. Surface water dissolved oxygen concentrations (mg/L) at Wainscott Pond (WPS) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). ND = No data collected for the date.

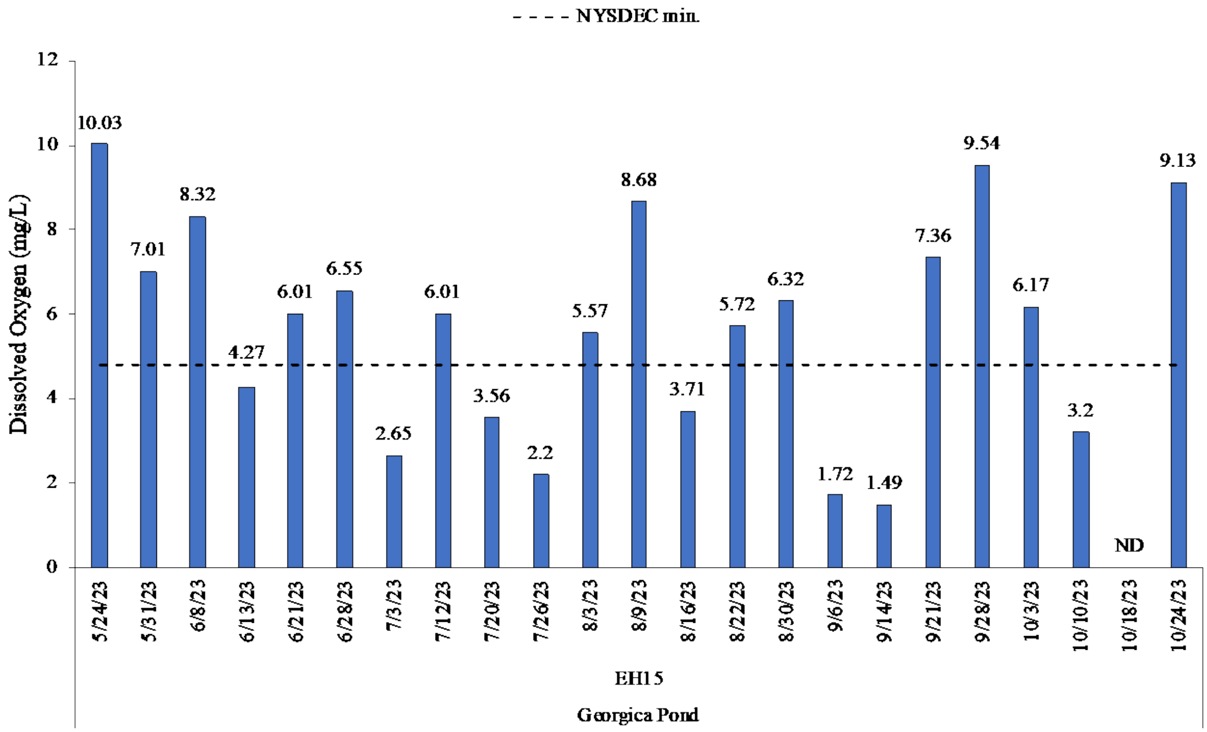


Figure 75. Surface water dissolved oxygen concentrations (mg/L) at a site in Georgica Pond (EH15) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). ND = No data collected for the date.

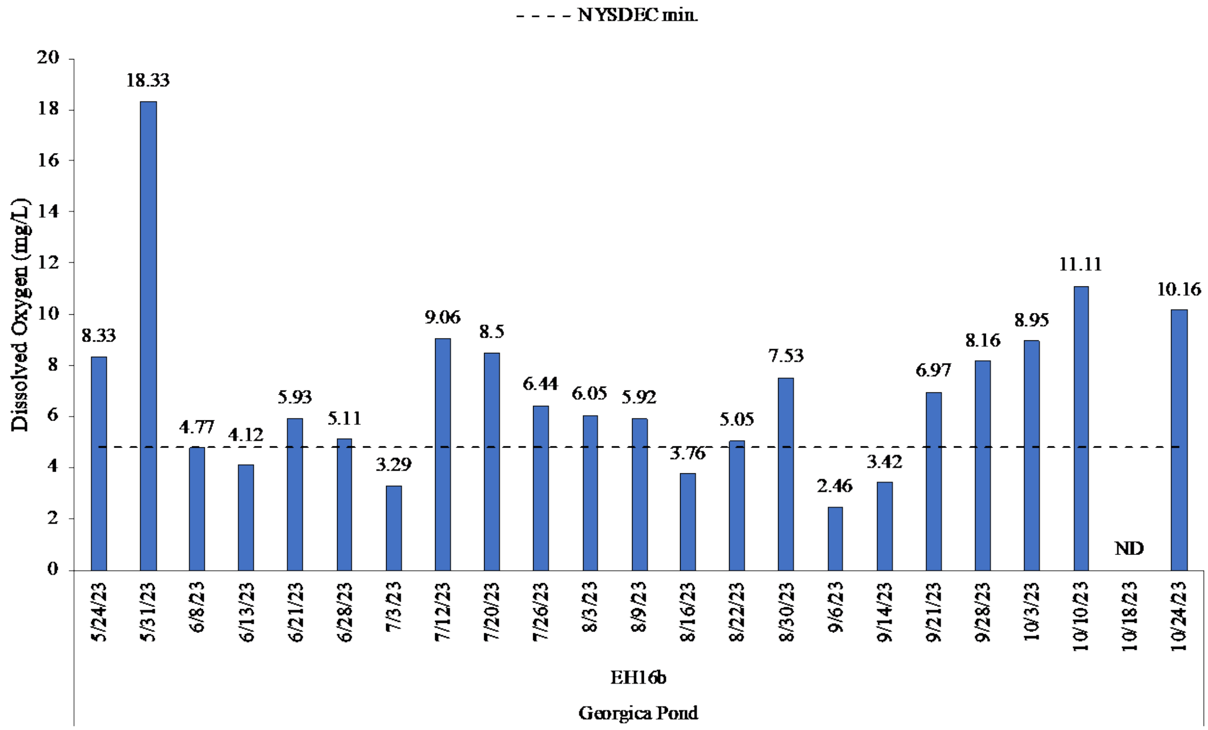


Figure 76. Surface water dissolved oxygen concentrations (mg/L) in a site in Georgica Pond (EH16b) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L). ND = No data collected for the date.

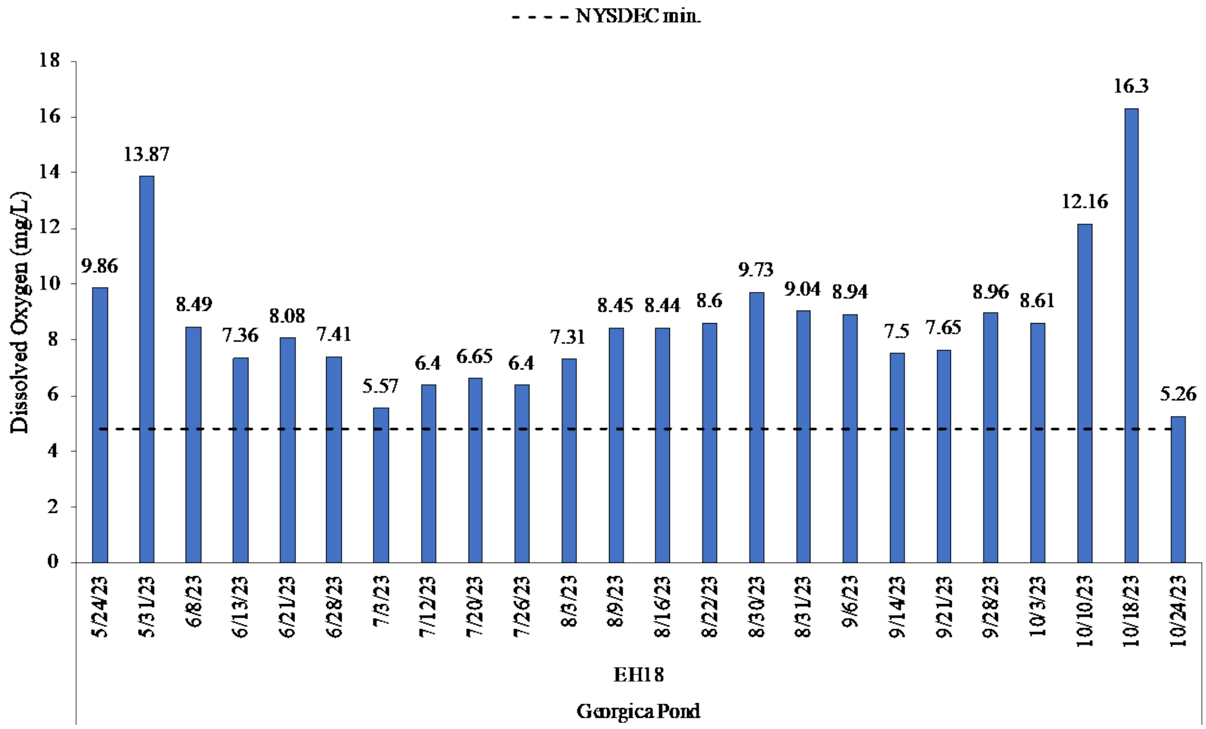


Figure 77. Surface water dissolved oxygen concentrations (mg/L) at a site in Georgica Pond (EH18) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L).

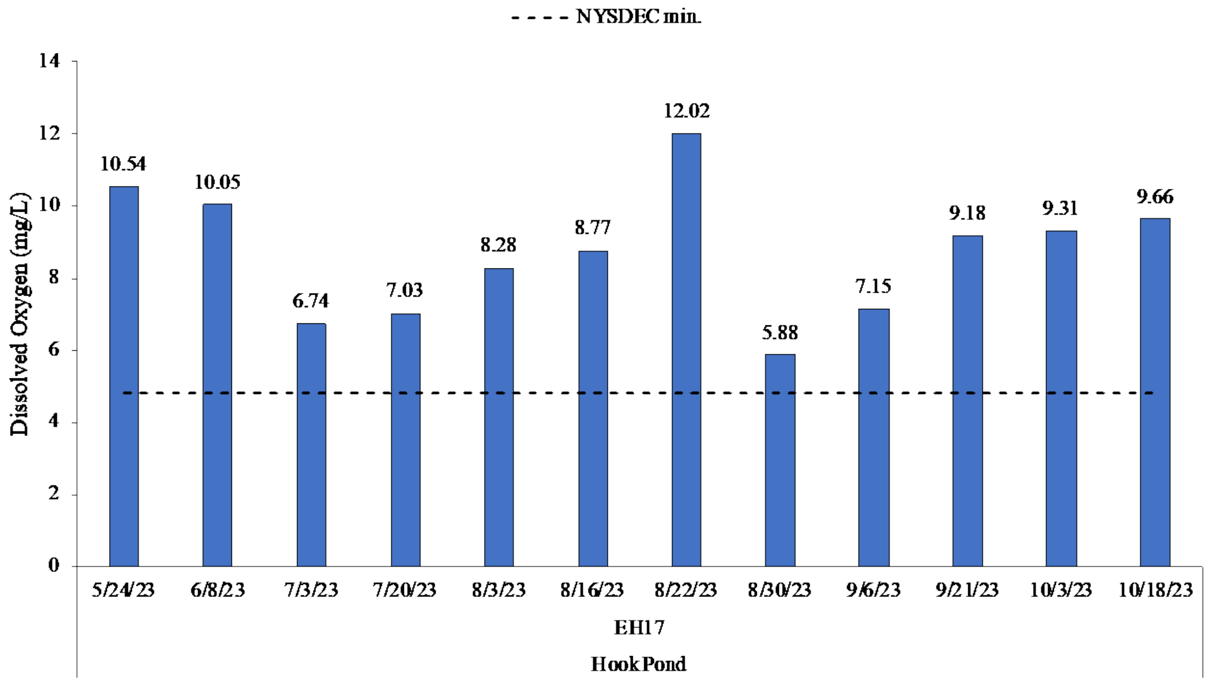


Figure 78. Surface water dissolved oxygen concentrations (mg/L) at Hook Pond (EH17) during 2023. The dashed line represents the NYSDEC minimum for dissolved oxygen (4.8 mg/L).

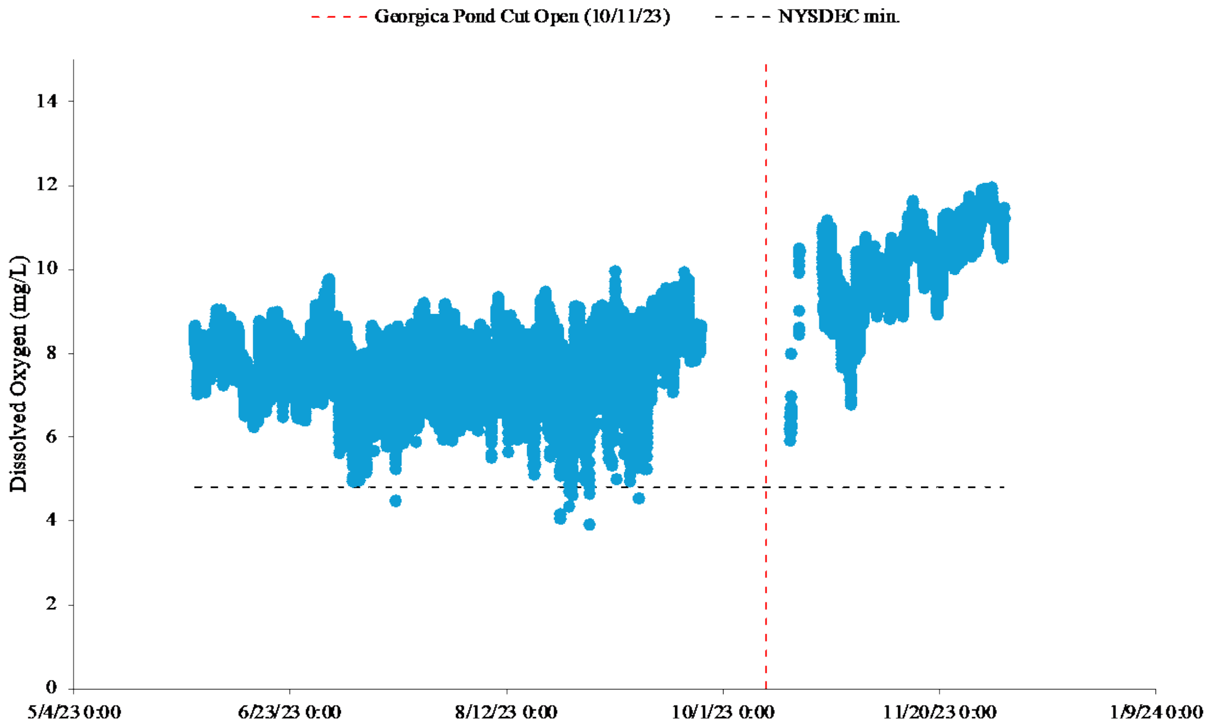


Figure 79. Continuous surface water dissolved oxygen (mg/L) at the buoy in Georgica Pond during 2023. The vertical dashed line represents when the ocean inlet in the south of Georgica Pond was opened on 11-October-2023. The horizontal dashed line represents the NYSDEC DO minimum (4.8 mg/L). Gaps in graph were when sensors were malfunctioning, and no data was recorded.

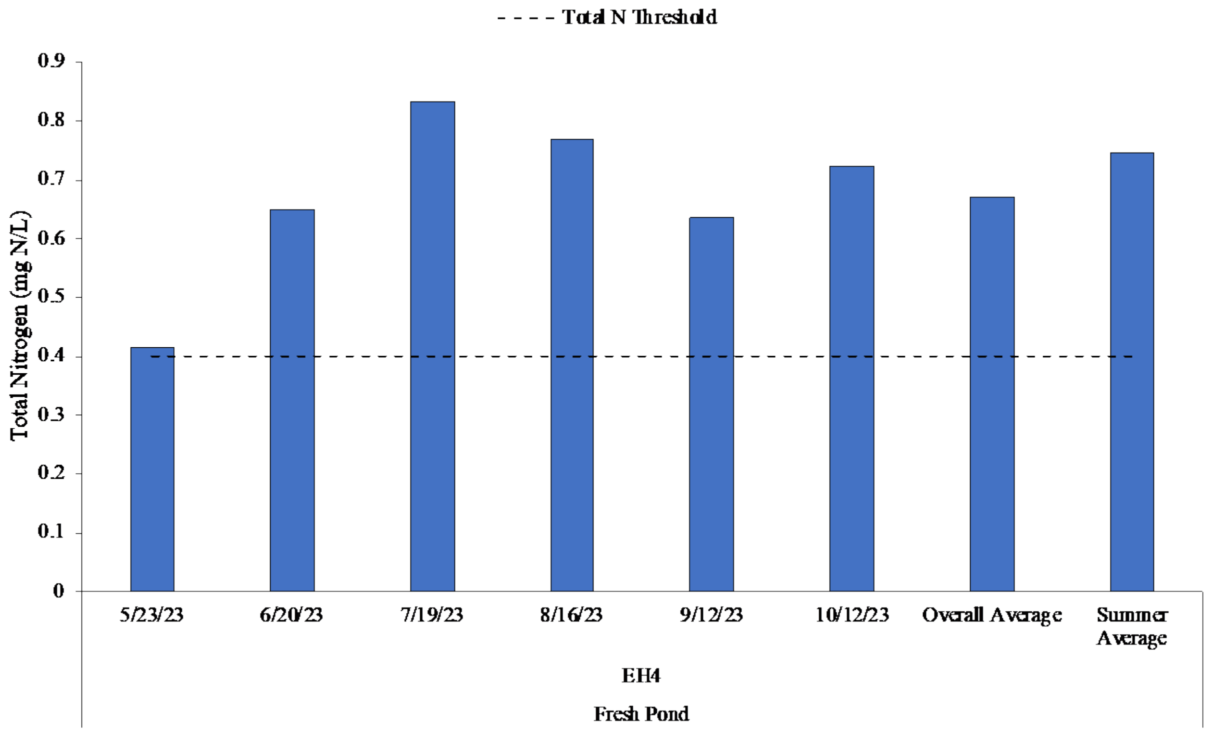


Figure 80. Total N, at Fresh Pond (EH4) during 2023. The dashed line represents the Peconic Estuary total N threshold (0.4 mg N/L). Error bars represent standard deviation.

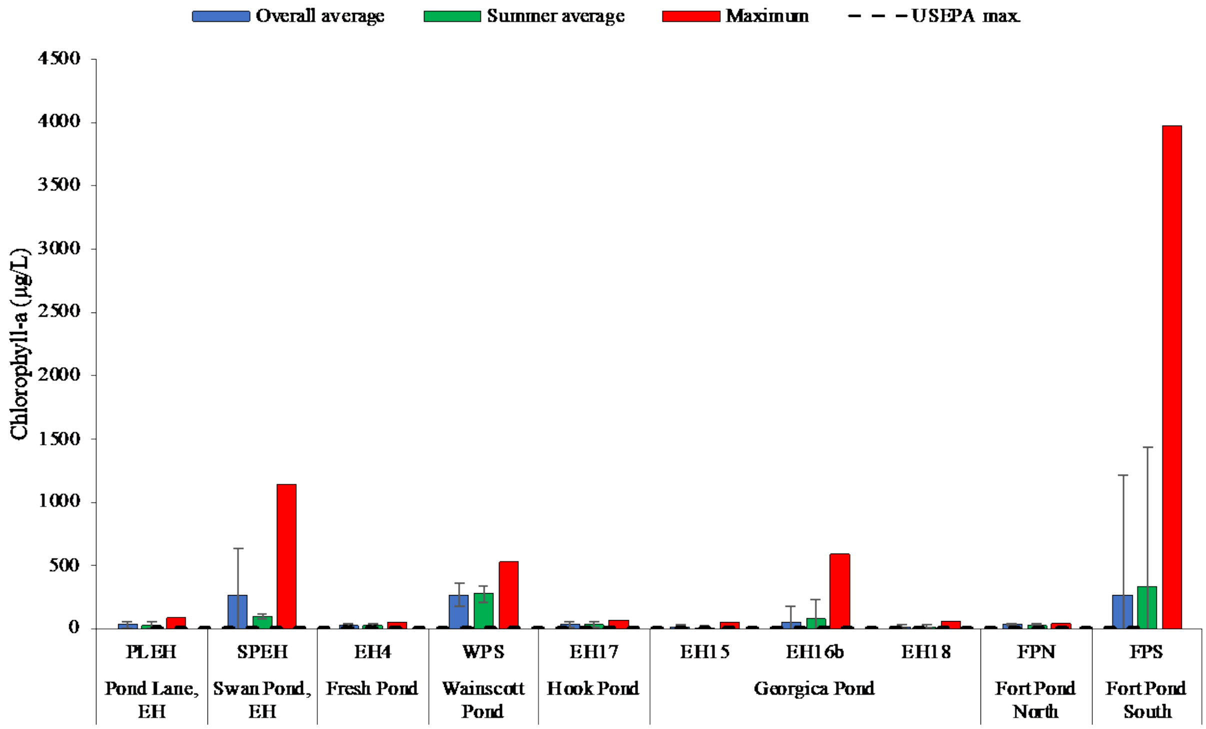


Figure 81. Overall average, summer average, and minimum chlorophyll-a concentrations (µg/L) at freshwater sites in East Hampton during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

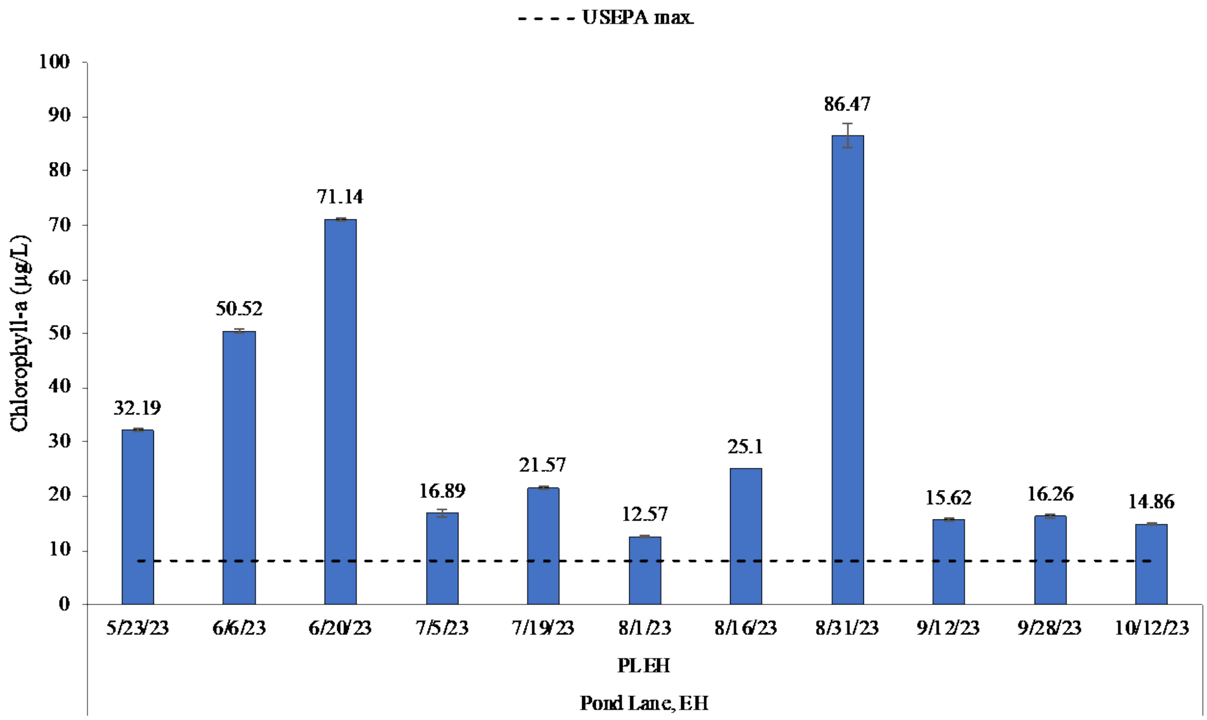


Figure 82. Chlorophyll-a concentrations (µg/L) in Pond Lane (PLEH) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

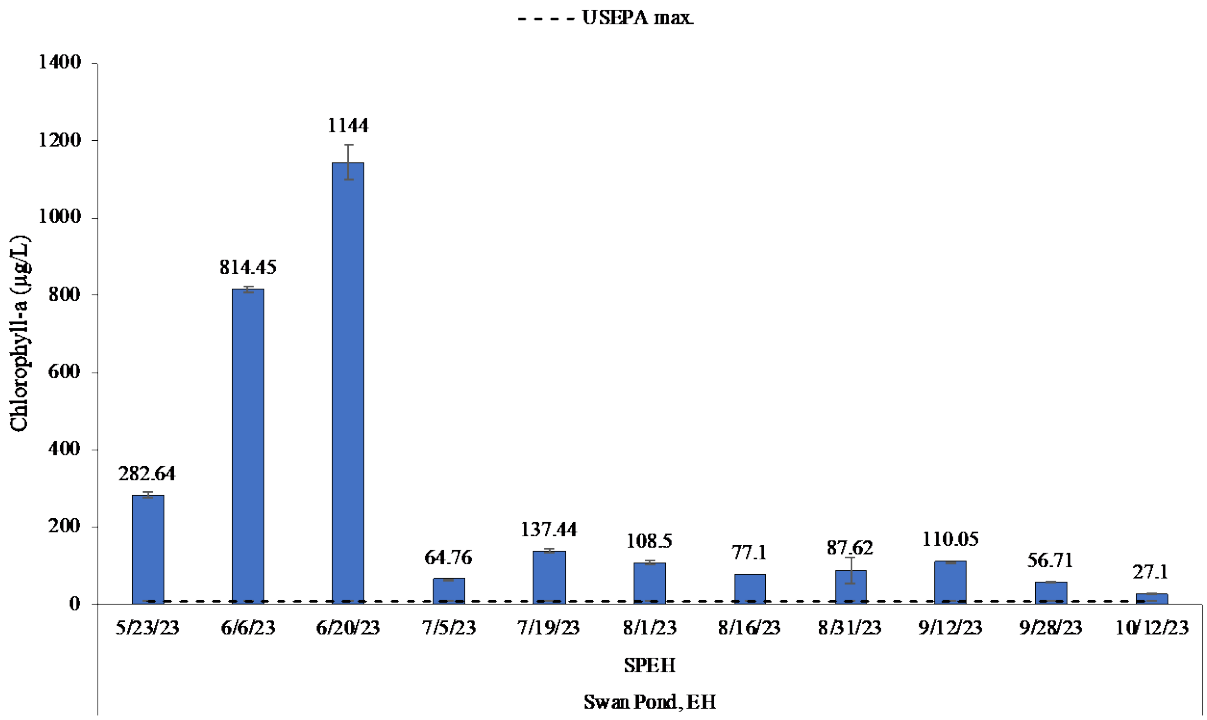


Figure 83. Chlorophyll-a concentrations (µg/L) in Swan Pond (SPEH) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

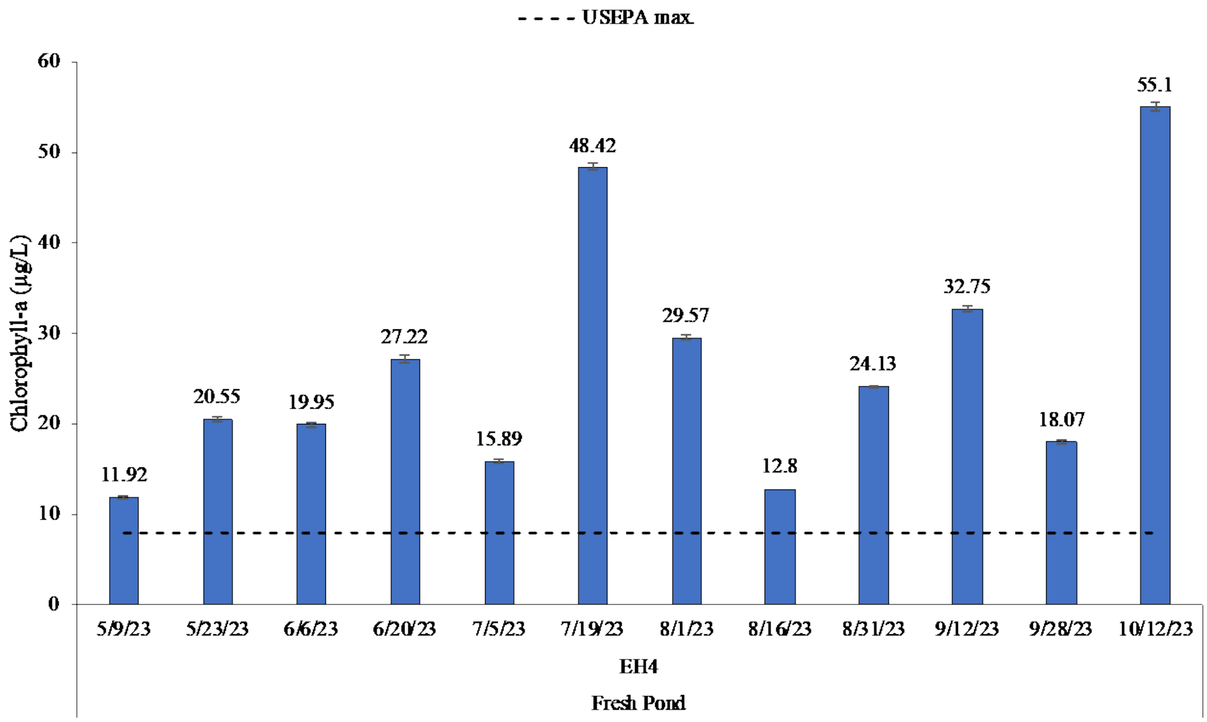


Figure 84. Chlorophyll-a concentrations (µg/L) in Fresh Pond (EH4) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

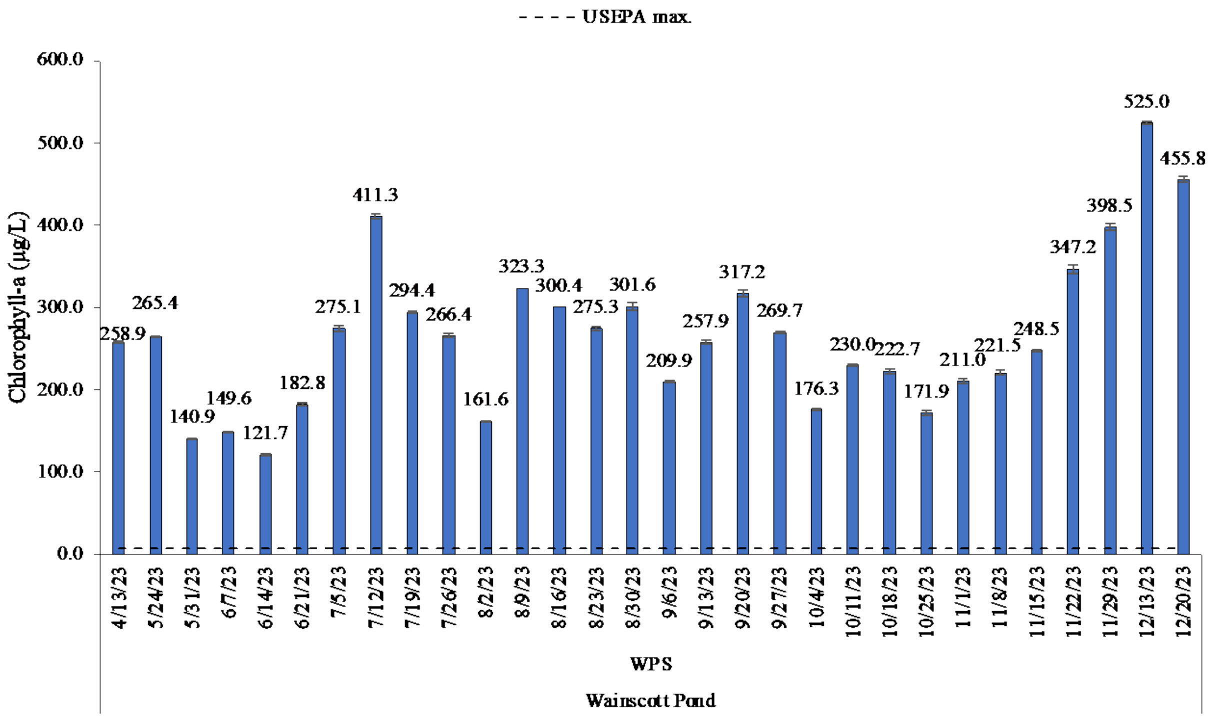


Figure 85. Chlorophyll-a concentrations (µg/L) in Wainscott Pond during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

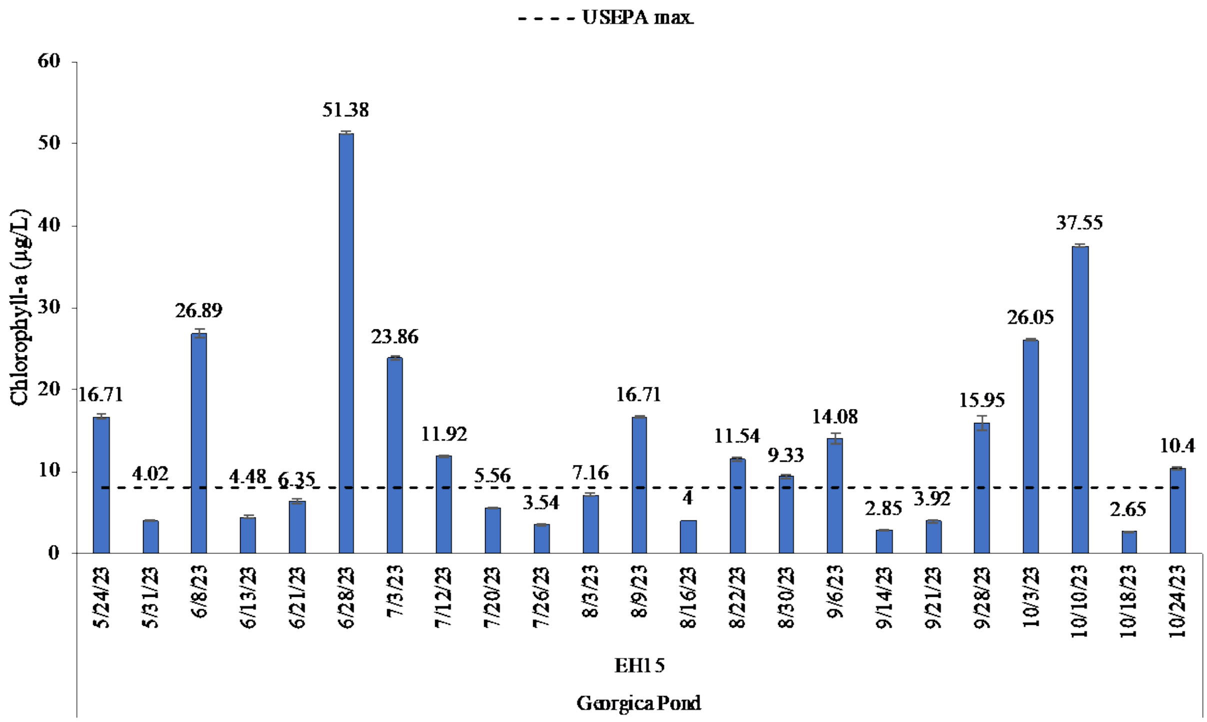


Figure 86. Chlorophyll-a concentrations (µg/L) in a site in Georgica Pond (EH15) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

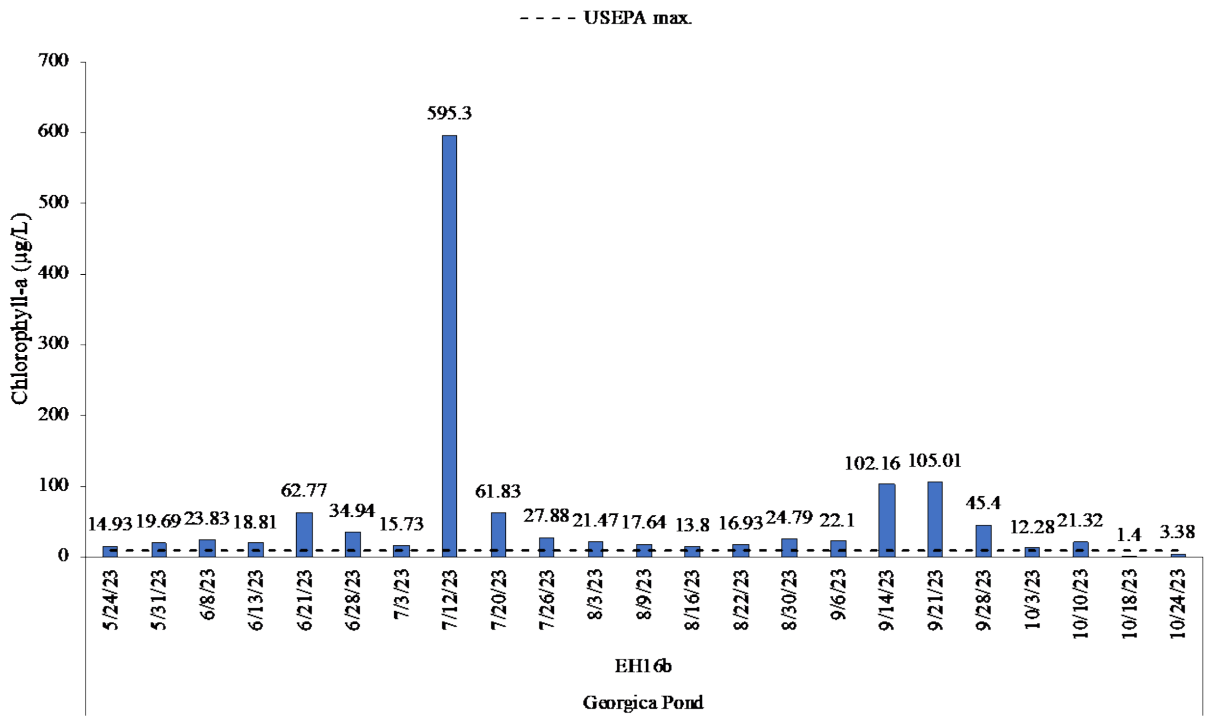


Figure 87. Chlorophyll-a concentrations (µg/L) in a site in Georgica Pond (EH16b) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

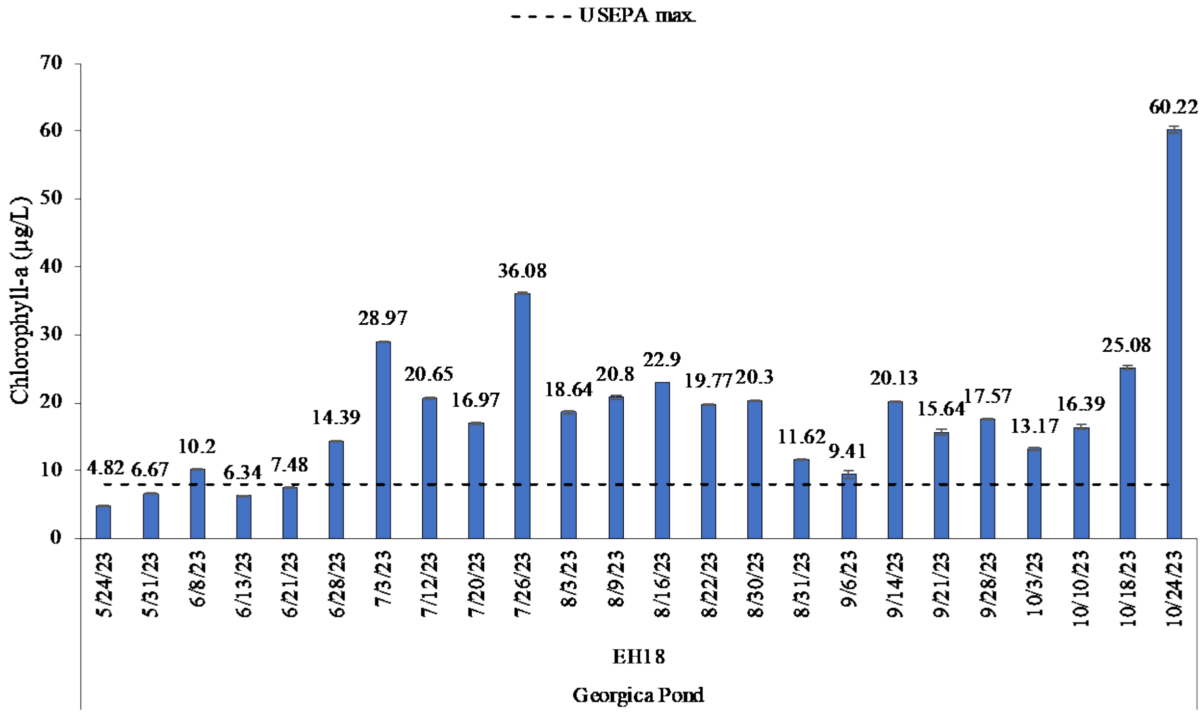


Figure 88. Chlorophyll-a concentrations (µg/L) in a site in Georgica Pond (EH18) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

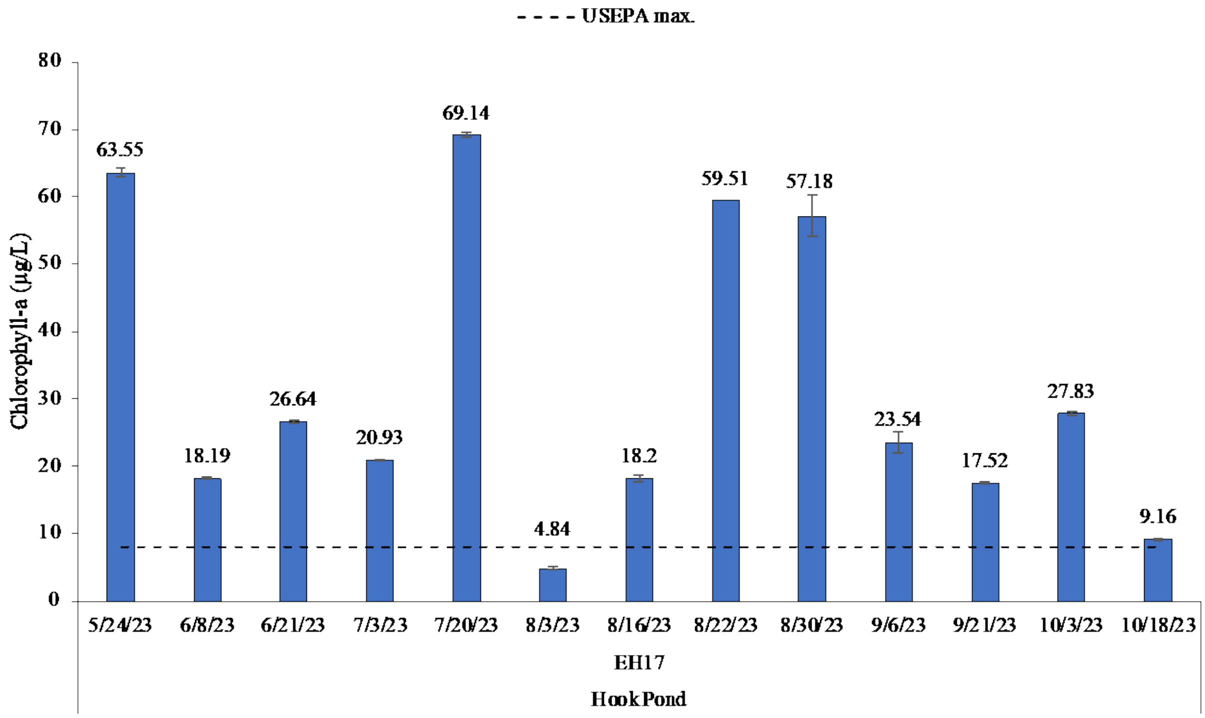


Figure 89. Chlorophyll-a concentrations (µg/L) in a site in Hook Pond (EH17) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

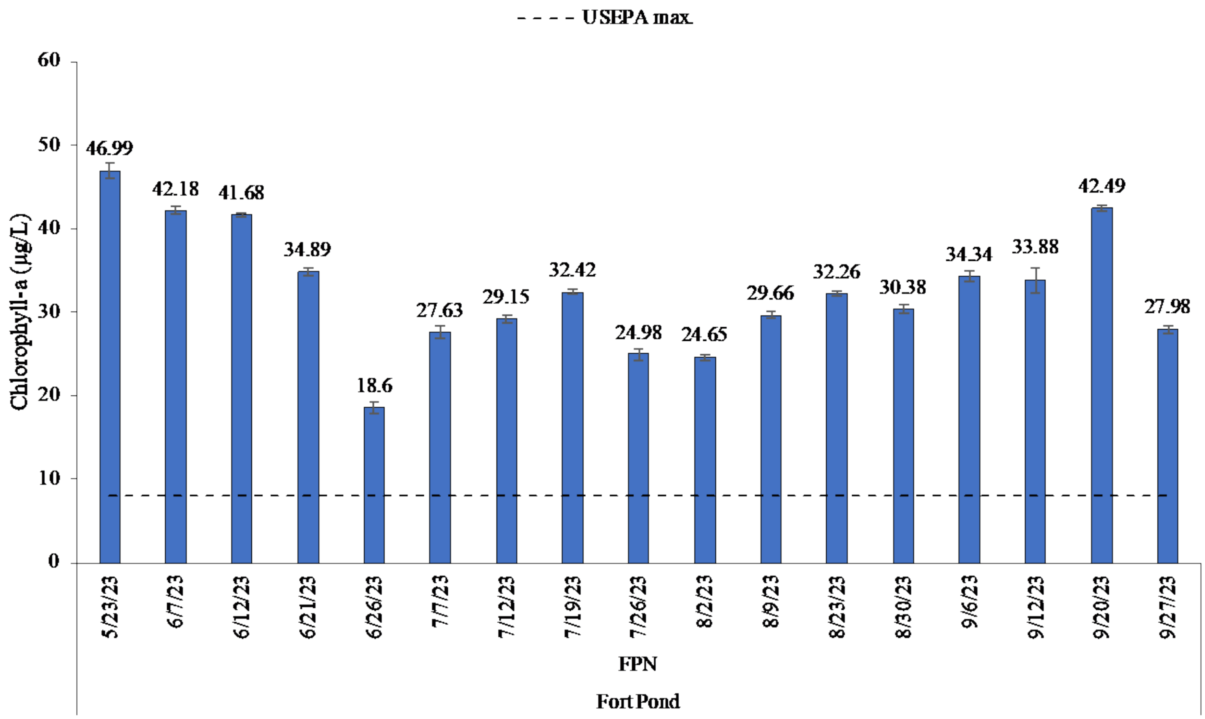


Figure 90. Chlorophyll-a concentrations (µg/L) in a site in Fort Pond (North) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

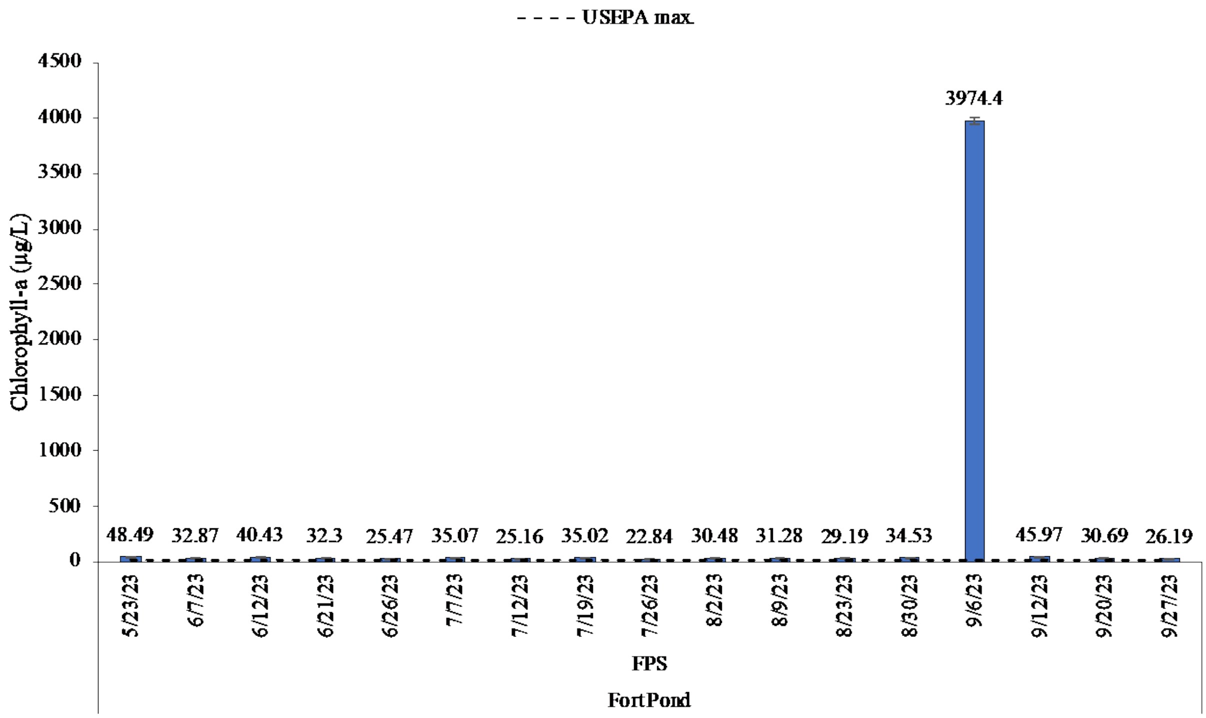


Figure 91. Chlorophyll-a concentrations (µg/L) in a site in Fort Pond (Spouth) during 2023. The dashed line represents the USEPA maximum for chlorophyll a in freshwater systems (8 µg/L). Error bars represent standard deviation.

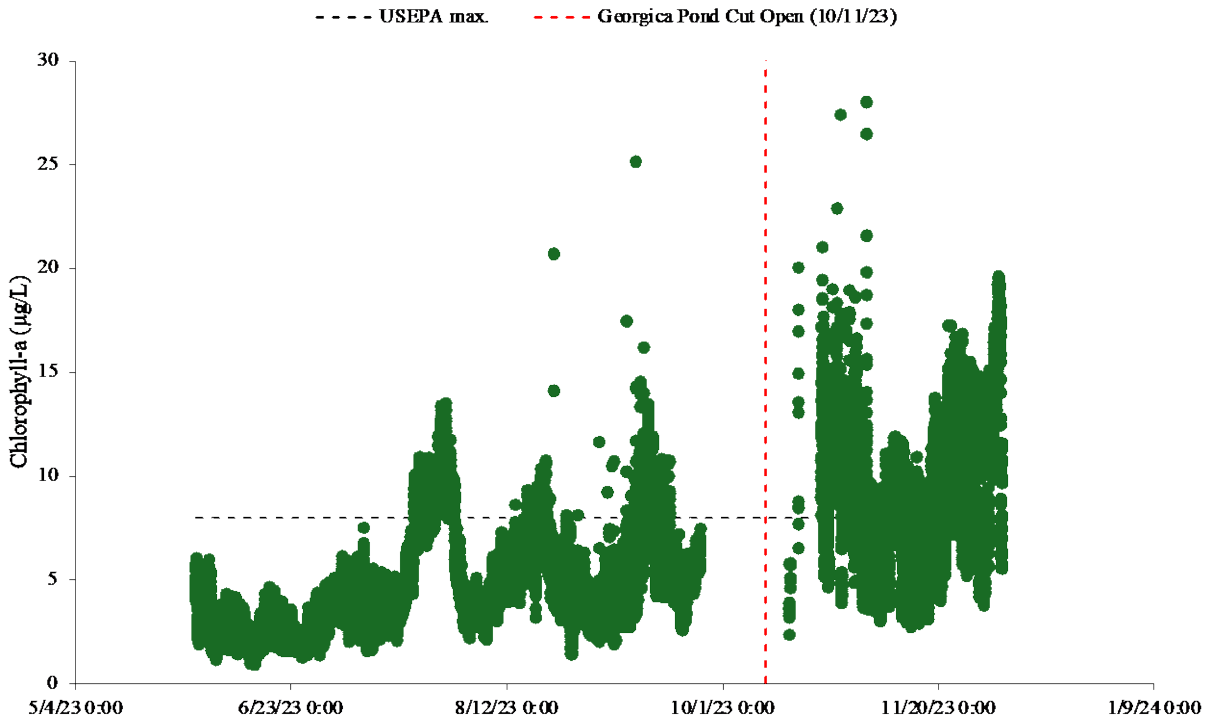


Figure 92. Continuous chlorophyll-a (µg/L) at the buoy in Georgica Pond during 2023. The vertical dashed line represents when the ocean inlet in the south of Georgica Pond was opened on 11-October-2023. Gaps in graph were when sensors were malfunctioning, and no data was recorded.

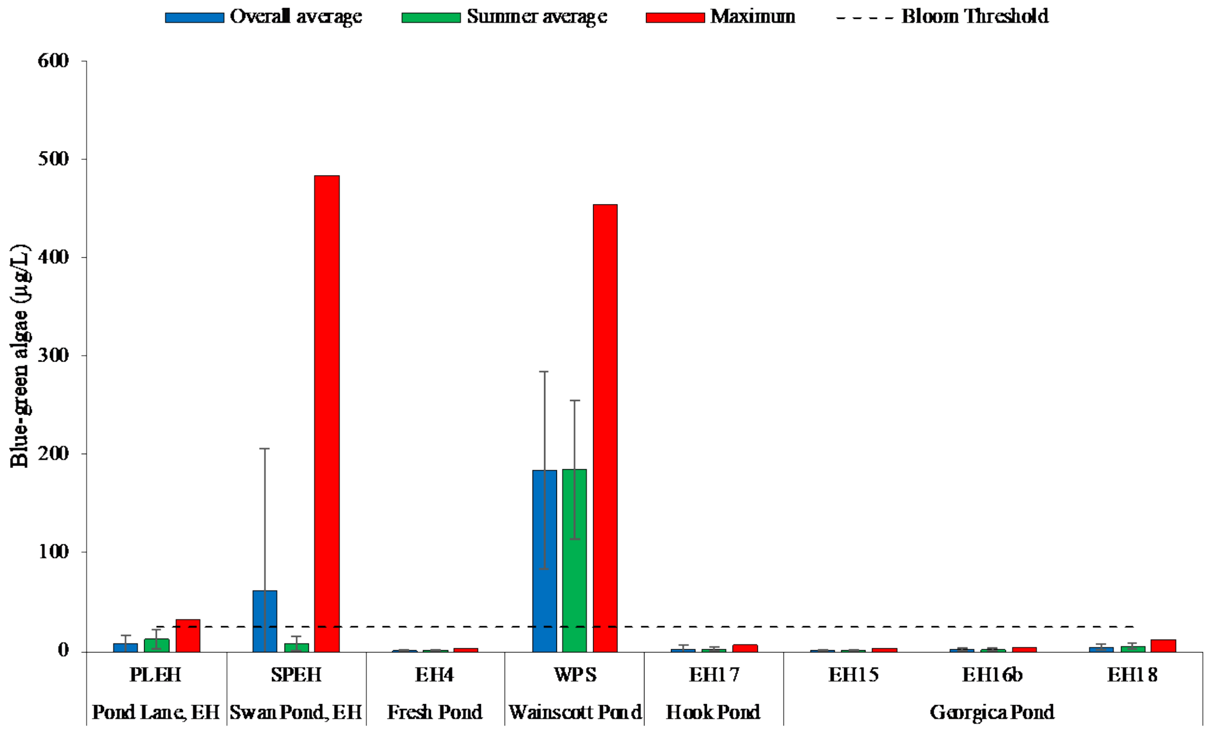


Figure 93. Overall average, summer average, and minimum blue-green algae concentrations (µg/L) at freshwater sites in East Hampton during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

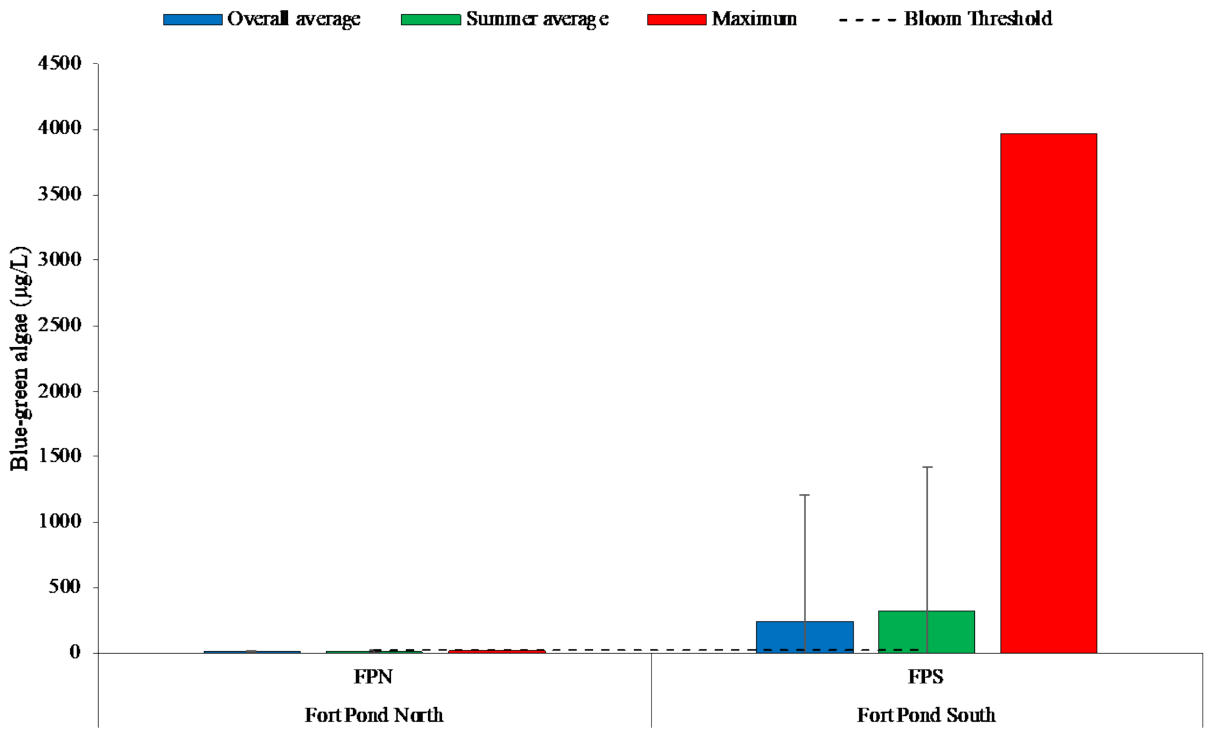


Figure 94. Overall average, summer average, and minimum blue-green algae concentrations (µg/L) at freshwater sites Fort Pond North and South during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

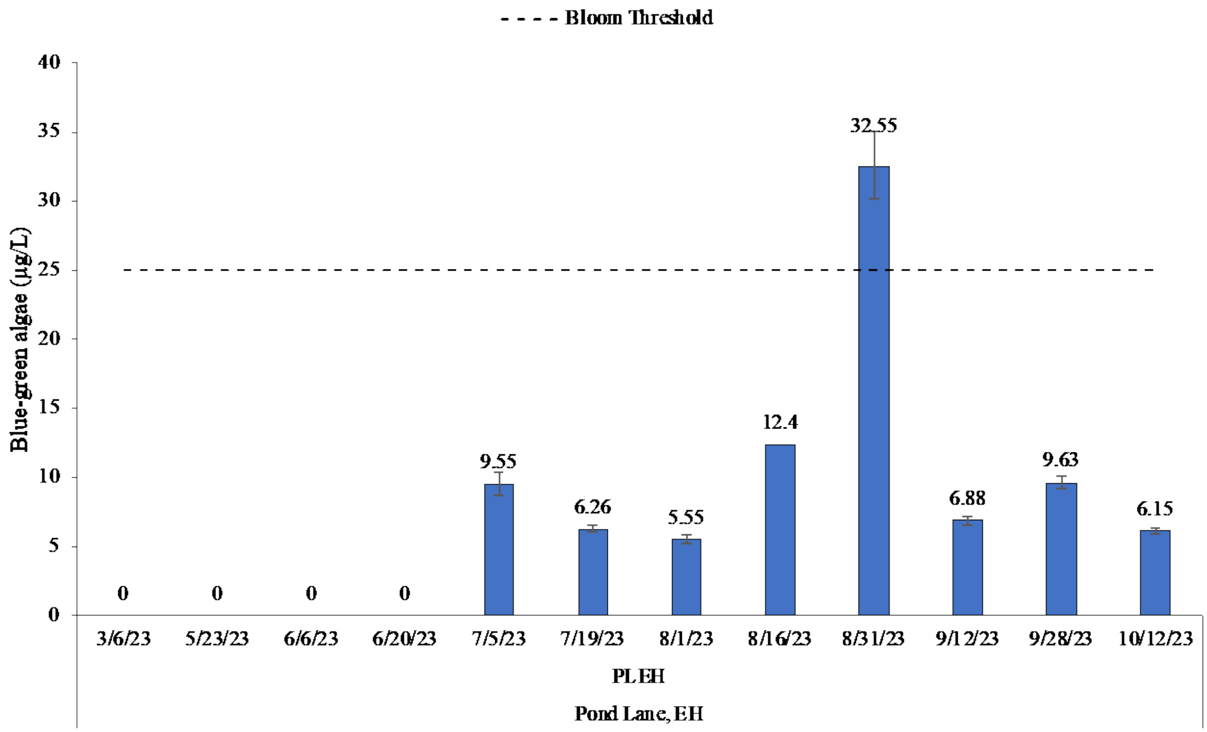


Figure 95. Blue-green algae concentrations (µg/L) in Pond Lane, EH (PLEH) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

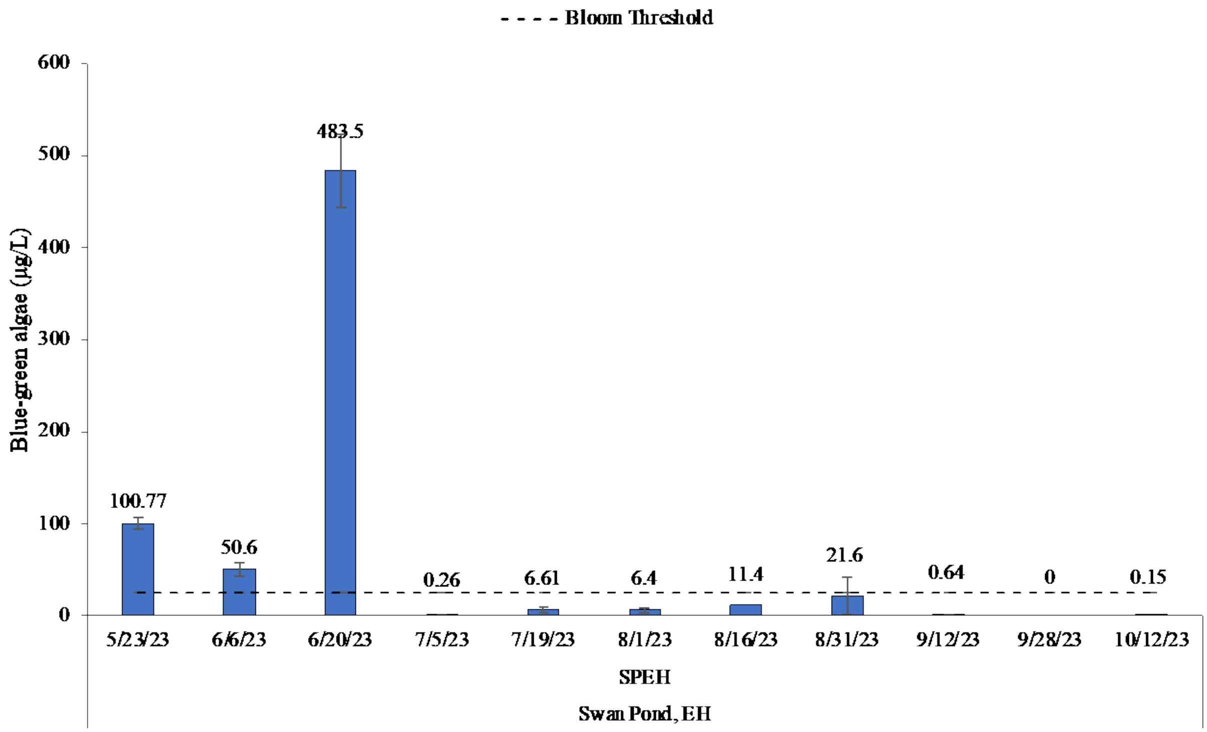


Figure 96. Blue-green algae concentrations (µg/L) in Swan Pond, EH (SPEH) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

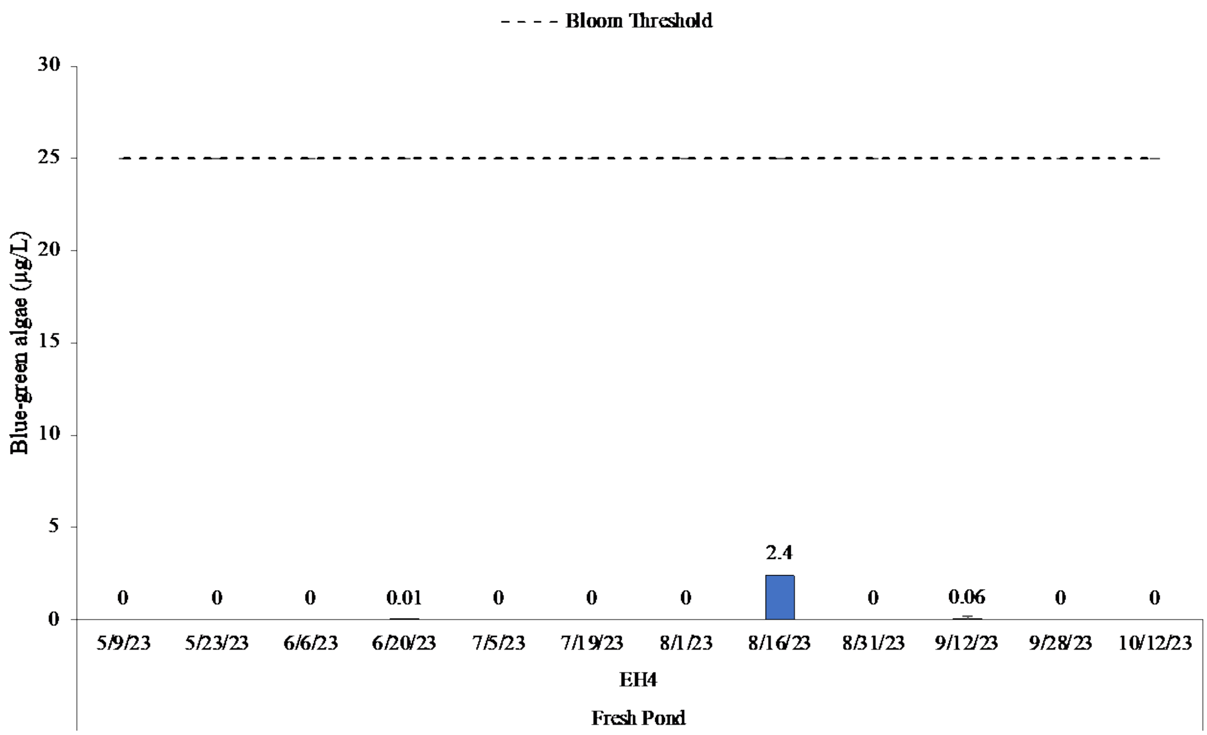


Figure 97. Blue-green algae concentrations (µg/L) in Fresh Pond (EH4) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

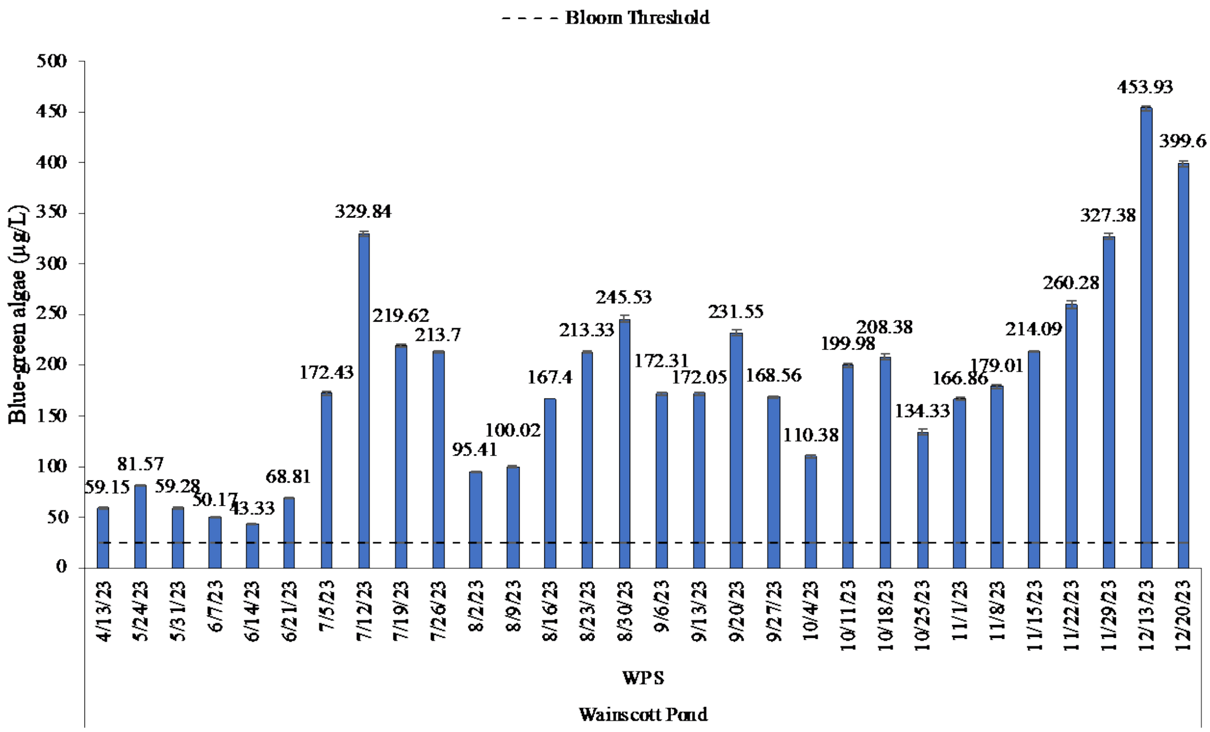


Figure 98. Blue-green algae concentrations (µg/L) at various sites in Wainscott Pond (WPS) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

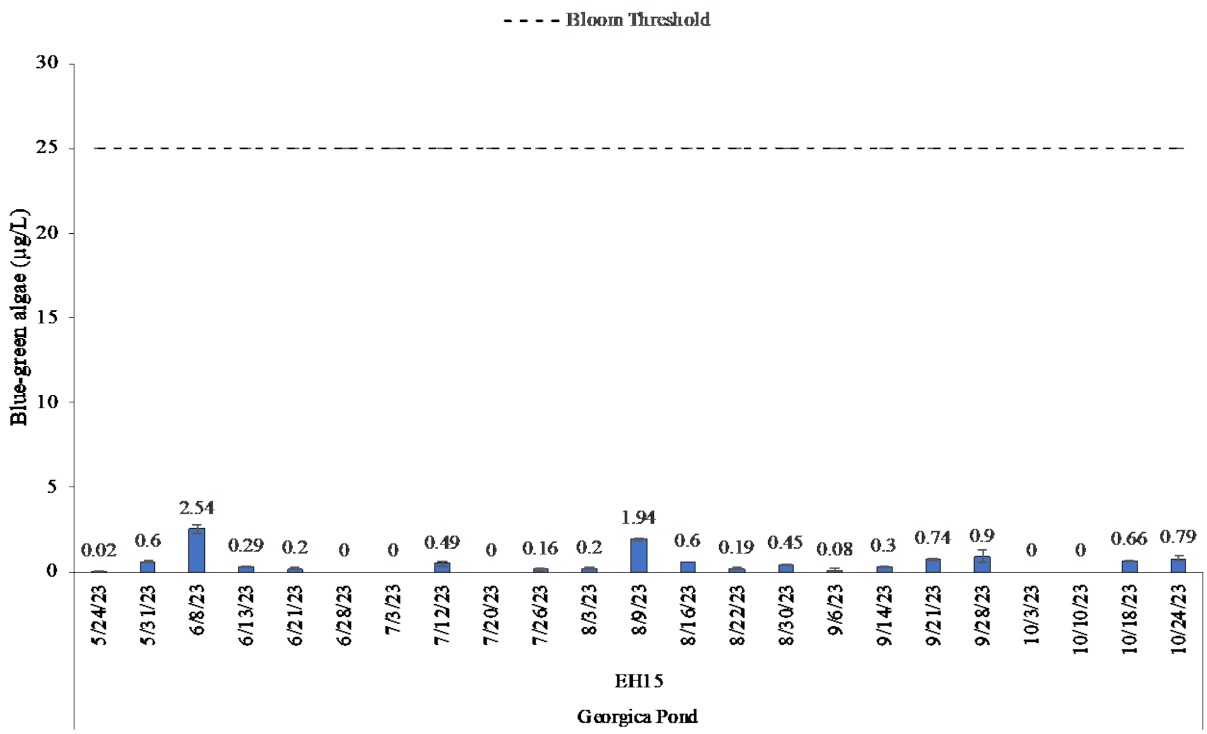


Figure 99. Blue-green algae concentrations (µg/L) in a site in Georgica Pond (EH15) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

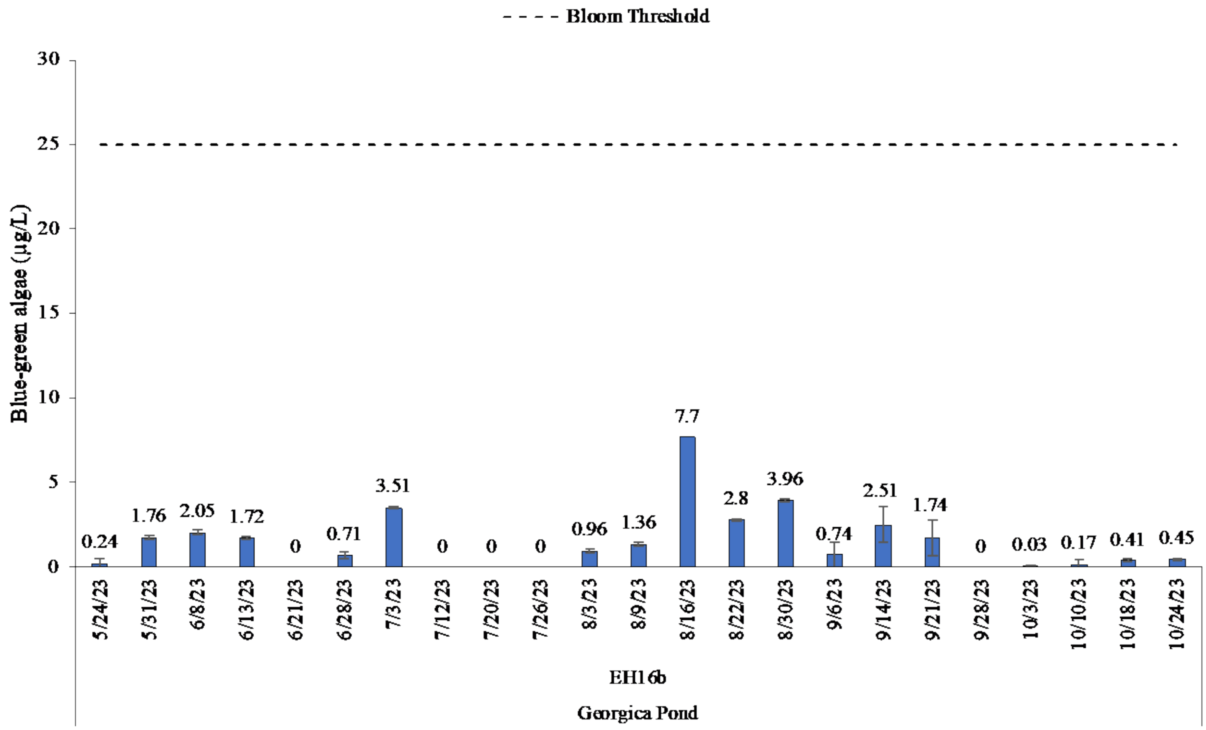


Figure 100. Blue-green algae concentrations (µg/L) in a site in Georgica Pond (EH16b) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

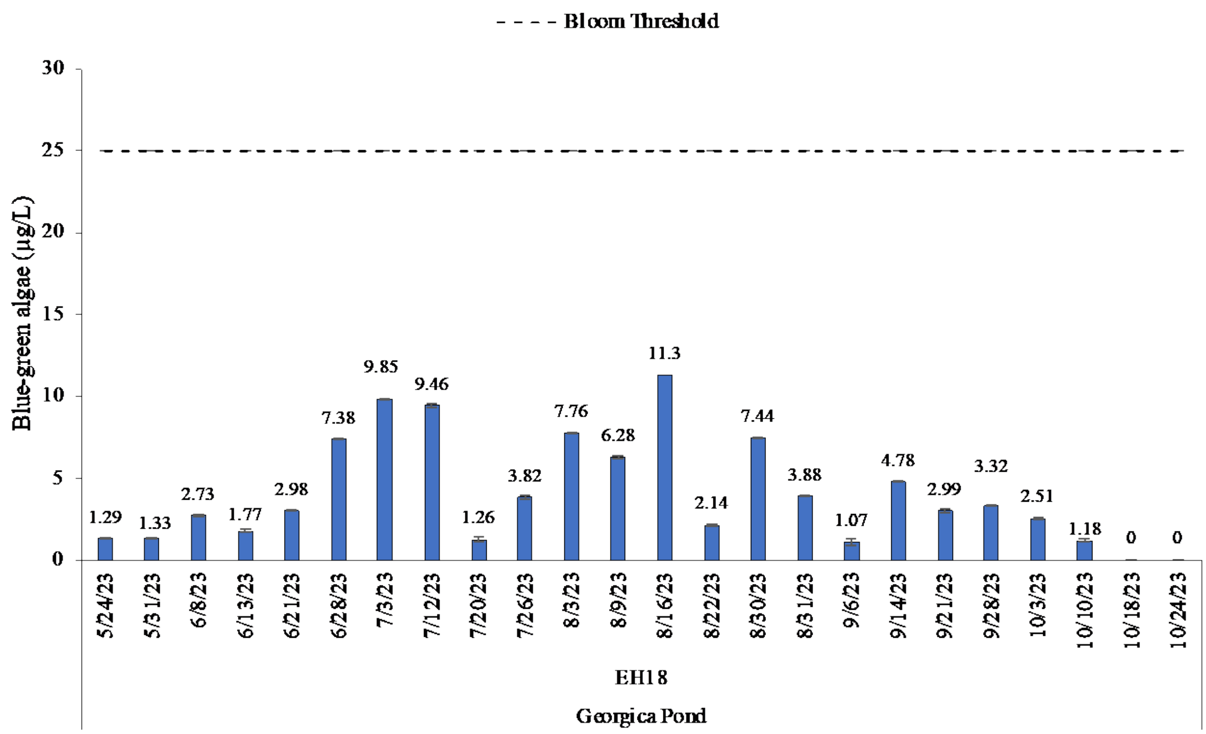


Figure 101. Blue-green algae concentrations (µg/L) in a site in Georgica Pond (EH18) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

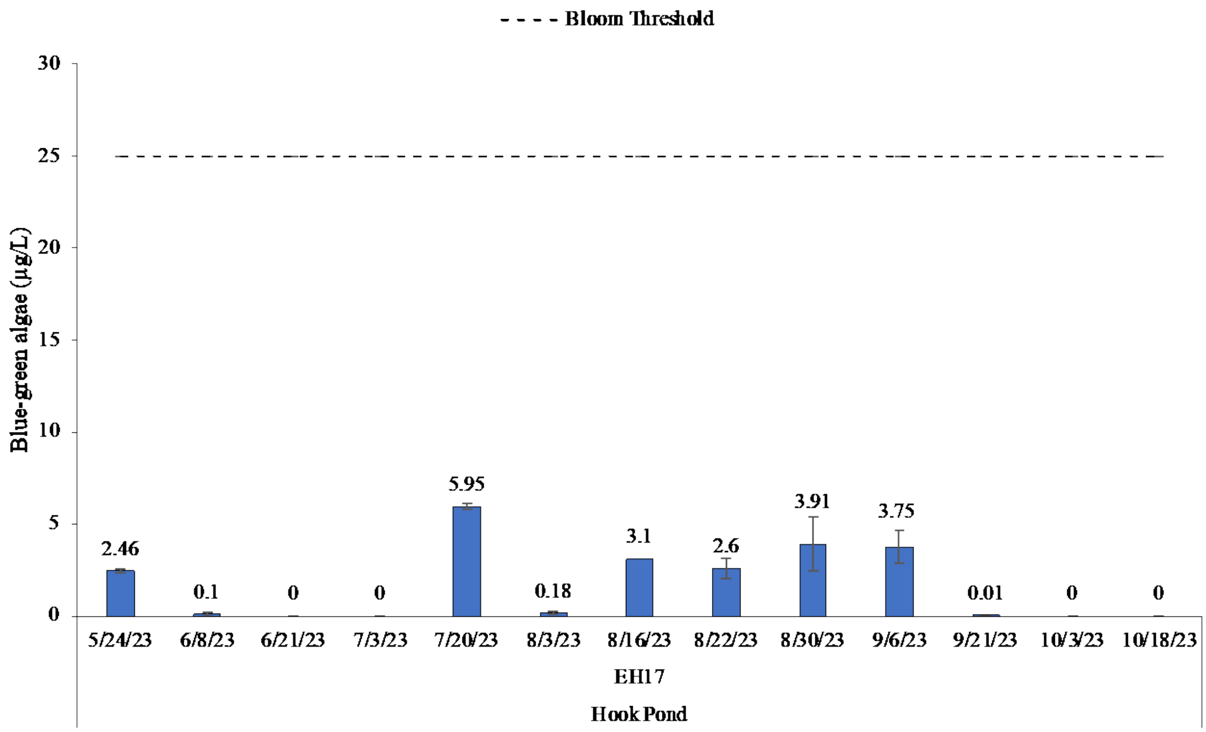


Figure 102. Blue-green algae concentrations (µg/L) in Hook Pond (EH17) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

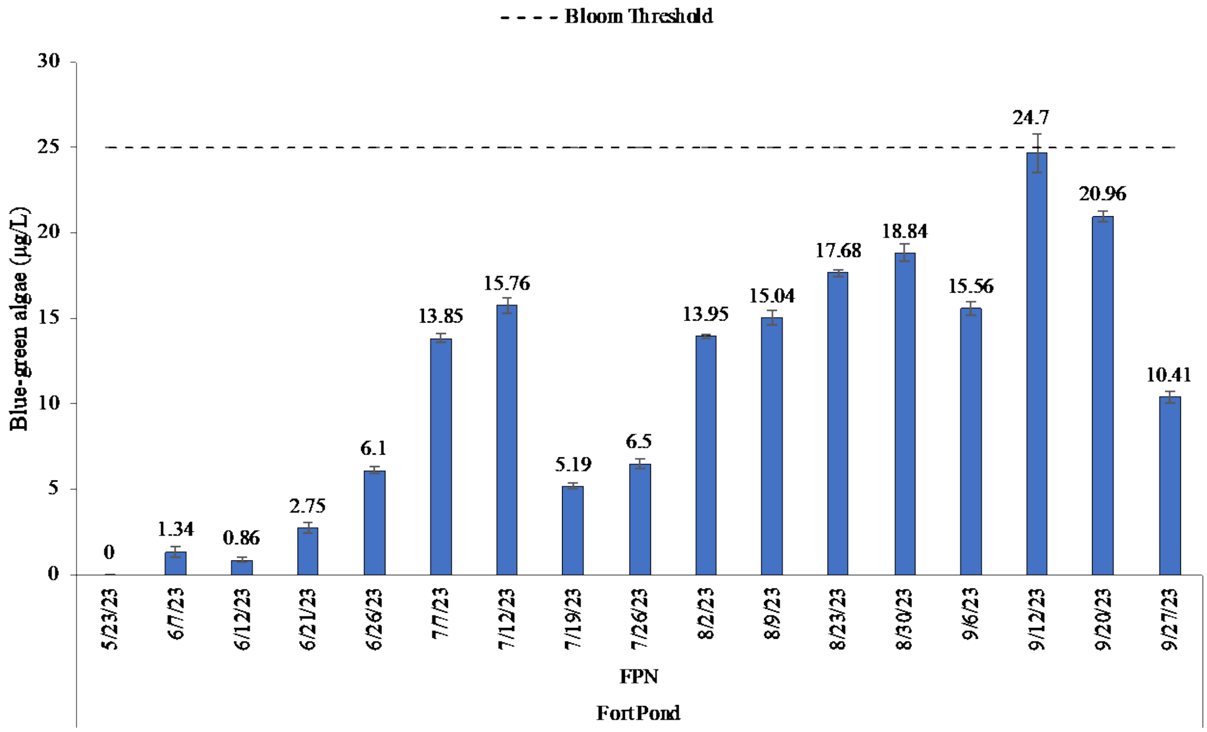


Figure 103. Blue-green algae concentrations (µg/L) in Fort Pond (North) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

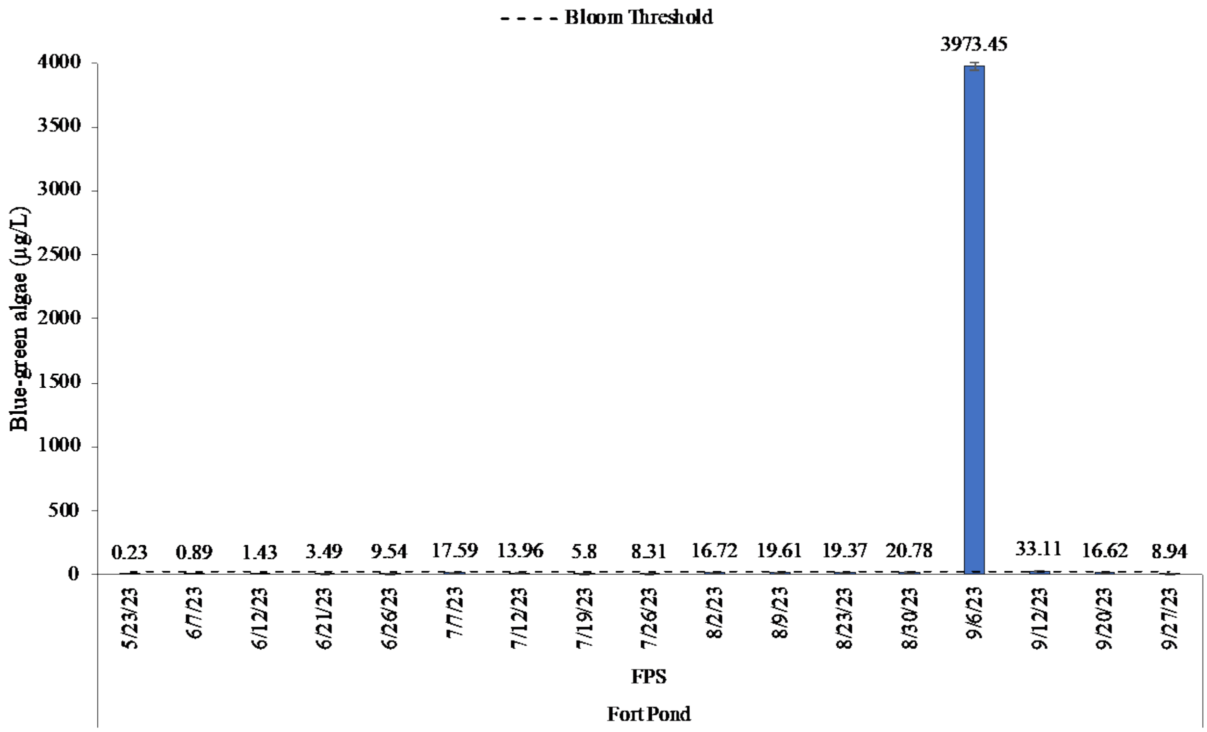


Figure 104. Blue-green algae concentrations (µg/L) in Fort Pond (South) during 2023. The dashed line represents the NYSDEC bloom threshold for blue-green algae (25 µg/L). Error bars represent standard deviation.

Table 2. List of cyanobacteria detected at each of the freshwater East Hampton sites in 2023.

Location	Site	Cyanobacteria Identified
Pond Lane, EH	PLEH	Aphanocapsa, Planktothrix
Swan Pond, EH	SPEH	Oscillatoria, Spirulina, Planktothrix
Fresh Pond	EH4	Not detected
Hook Pond	EH17	Not detected
Georgica Pond	EH15	Not Detected
	EH16B	Not Detected
	EH18	Not Detected
Wainscott Pond	WPS	*Aphanizomenon, Dolichospermum, Microcystis, Planktothrix, Cuspidothrix*
Fort Pond	North	*Aphanizomenon, Planktothrix*
	South	*Aphanizomenon, Planktothrix, Dolichospermum*

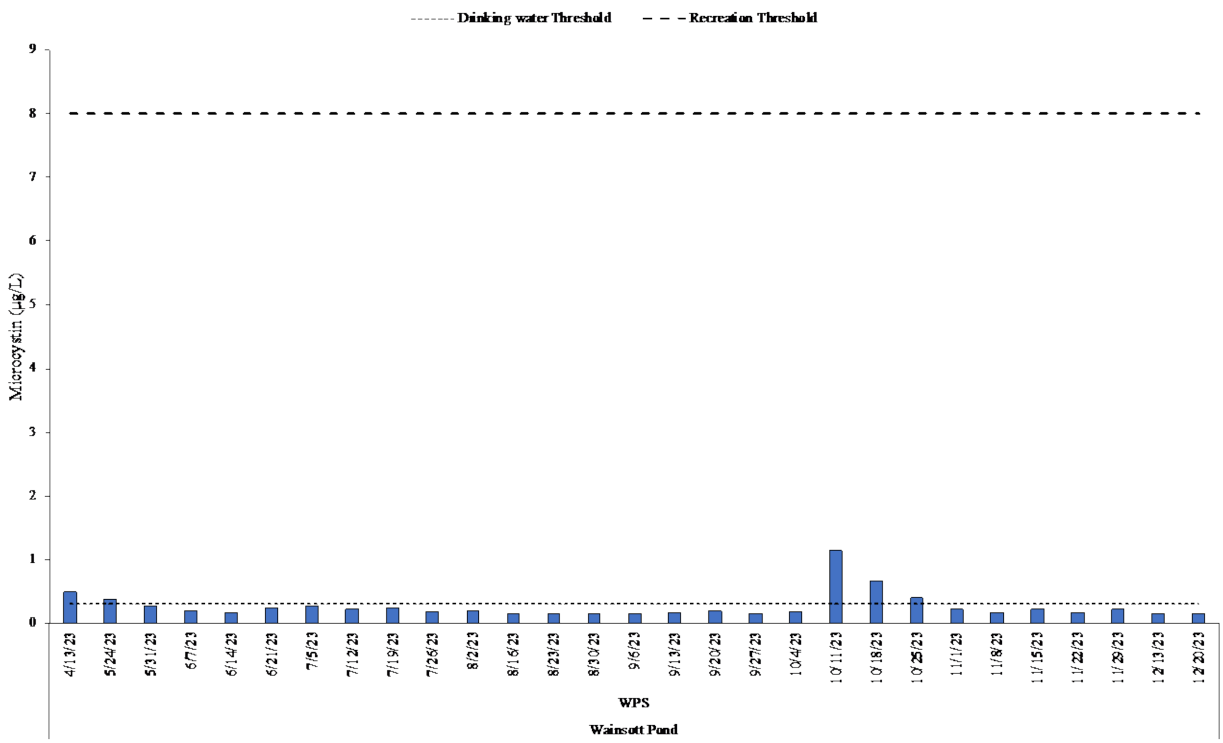


Figure 105. Microcystin concentrations (µg/L) at Wainscott Pond during 2023. The standard thresholds for drinking water and recreation are 0.3 and 8 µg/L, respectively.

Table 3. Microcystin toxin (µg/L) values of various sites in 2023.

Location	Site	Date	Microcystin Toxin (µg/L)
Pond Lane, EH	PLEH	31-August	0.31
Swan Pond, EH	SPEH	23-May	0.23
		6-June	0.26
		31-August	<0.15
Georgica Pond	EH18	9-August	<0.15
		30-August	<0.15
		31-August	<0.15
		3-October	<0.15
		10-October	<0.15
Fort Pond	North	12-September	<0.15
		20-September	<0.15
	South	6-September	2.94
		12-September	0.37